An Analytical Study of Child Survival using the Sudan, Egypt and Yemen PAP-CHILD Surveys

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Abstract

The thesis is a comparative study of, Egypt, Sudan and Yemen, three countries with similar social and economic profiles, yet with a variable dynamic in achieving reductions in child mortality levels. The study begins with a consideration of the individual country backgrounds and then presents comparative findings on population health and child survival. Empirical results on the correlates of child survival are presented, together with a selective review of the related techniques of analysis. The analyses of survival to age five was based on data from the PAP-CHILD surveys carried-out in Egypt (1991), Sudan (1992/93) and Yemen (1991/92). The aim was to investigate the determinants of child survival with the innovation of adjusting for the effect of a family's "child mortality background". Methods of analysis included life-table analysis, logistic (marginal and multilevel) and Cox regression models.

The transition to better child survival could further benefit from the spacing of births, the avoidance of higher-order births, and the concentration of childbearing in the central reproductive ages. Unequivocally, deaths of older siblings prior to the birth of every index child were strong predictors of poor survival settings. Deaths of older siblings after the birth of the index child were rare, yet captured "immediate" risk spells. Events of conception, birth and death of a subsequent sibling entailed time-varying excess risks. Evidently, adjusting for measures of familial child losses explains much of the "between-households" variation in mortality risks and spell-out "within-households" inter-dependencies of survival. Households further correlate in risks to child survival when they belonged to the same geographical cluster. The novelty in representing the latter correlation with a "regional" component of unmeasured effects was in aid of pertinent policy recommendations.

Further, the study makes recommendations on reducing reporting errors of demographic data collected from mothers. Critical findings and policy implications are: for Egypt, better child survival rates are achievable by narrowing "regional" socio-economic gaps and sustaining lower fertility rates; in Sudan, the slowing pace of declines in child mortality were not best explained by relations with observed correlates, and appears further underpinned by the country's economic crisis; in Yemen, child mortality levels *can* be reduced by a third if the timing between successive births could be extended to two years, *net* of *key* promotive socio-economic interventions.

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CHAPTER 1

CHILD SURVIVAL: HISTORY AND BACKGROUND

1.1 Child Health / Child Survival, Why does it matter?

In every society whether developed or developing, population well-being remains an important driving force behind its future advancement if not for the sake of mere survival and global representation. The level of mortality in infancy and childhood is an important indicator of the health of the population. Many populations of the developing world today face major hurdles on the path and pace to of sustaining economic and societal development given their high population growth rates and slowing rates of mortality decline.

Population dynamics react interchangeably to any change at all levels - starting from the highest community or societal level, to the familial level and further down to the micro child level. At the community or societal level, the health improvements of the past few decades have done much to enhance human welfare, both directly and indirectly. Improved health contributes to a country's economic growth in four ways: it reduces production losses caused by worker illness; it permits the use of natural resources that had been totally or nearly inaccessible because of disease; it increases the enrolment of children in school and makes them better able to learn; and it frees for alternative uses resources that would otherwise have to be spent on illness.

For the familial level, more confidence in child survival induces an effect on attitudes towards child rearing. More confidence in child survival remits back to parents a feeling of security and may be better planning and prediction of the future ahead. Hence, young parents will aspire to plan and sustain smaller family sizes, made-up of healthier members, with access to basic needs of survival such as safe-water supplies, better sanitation, accessible health care systems and educational systems.

At the child level, prospects of better survival are healthier children enjoying all the benefits of parental and societal care in the shape of better health care, immunisation from diseases, educational opportunities, and consequently better futures and standards of living.

The level of child mortality is an important index of the level of a country's development or economic retardation. Comparing levels of child mortality for developing and developed countries there still remains a discouraging mammoth difference between the two. This could leave a dark picture of child mortality given the future of developing countries, but there also exist success stories for countries which managed to lower child mortality levels despite low levels of economic development.

Infant and child mortality rates in many parts of the Middle East and North Africa have been decreasing in recent decades, but remain among the highest in the world. Although the decline in mortality is fairly well documented, it has been difficult to determine the relative importance of various diseases and conditions as causes of death among children of different age groups. Often, data on causes of death are incomplete and of questionable quality, but virtually all studies report that measles, diarrhoeal diseases, acute respiratory infections (ARI) and malaria are the leading causes of death for children less than five years of age. Many causes of death can be prevented through vaccination programmes. Commonly vaccinated against childhood diseases are measles, pertussis (whooping cough), tuberculosis, tetanus, diphtheria and polio.

It was realised in the 1960s that rapid mortality declines of the post World War II period resulted in rapid population growth of third world countries. Studies revealed that this rapid growth rate could severely limit the efforts of governments to achieve sustained growth and to provide for the basic needs of their populations. By the 1970s, many third world countries had responded to the challenge posed by rapid population growth through formulating policies to moderate growth rates. The main instrument of these policies was a family planning programme. But again, just as these were being set up, a massive debate began about the potential viability of these programmes vis-à-vis scarce resources allocation to the provision of basic needs. The central point in the controversy was the assumption that fertility decline was largely a function of socio-economic development and unless some 'threshold' of development was achieved, family planning programmes could not possibly have more than modest effect in this context.

Half way between the two sides is the view that population and development are interrelated. Population concerns broadened from preoccupation with fertility reduction to concerns about high morbidity and mortality, status of women, poverty, population mal-distribution, international migration and a youthful population age structure. To some extent the lack of economic growth in many parts of the developing world has further aggravated the effect of these burdens. The implication of all this was the resulting call to view socio-economic and demographic outcomes within an integrated framework.

For some governments there remain many complications to providing *health for all*; as an example if governments work towards income growth this is expected to have more impact in poor populations. Income growth implies additional resources to buy basic necessities, particularly food and shelter that yield high health benefits. Moreover, the distribution of income and the number of people in poverty matter as well. In developing countries the number of people in poverty is an especially important reason for differences in health. One study looked at 22 developing countries with comparable data on poverty (defined as the share of the population consuming less than $1 a day at 1985 purchasing power parity prices) and found that the variation in the prevalence of poverty and in per capita public spending on health is important in explaining cross-country variation in life expectancy-more importantly when compared than differences in per capita income (World Bank 1993: p.40).

In the past, mortality reductions were a natural response to the three instrumental factors mentioned earlier, which will continue to play a role in reducing mortality in the future. However, the most direct way in which governments can intervene to reduce mortality in the short run is through increased provisions of health services. The ability of many governments to provide health services is limited by the small amount of money available for the health sector. The extent of political and economic organisation in a country seems to play a major role in mortality reduction. Countries where political unrest, war and famine disrupt the social organisation tend to have a stagnant mortality and in some cases rising mortality rates (Ewbank and Gribble, 1993).

At the familial level, a number of factors, combined or otherwise, contribute to higher mortality levels amongst population groups. Hence, households are expected to vary more across communities and to vary less within communities. To further granulate the argument, children's experiences are expected to be more similar within the same household than for those belonging to different households. Within communities, households are expected to share common utilities, such as access to sanitation, clean water supply, health care, educational institutions and many more geographical and socio-economic variables. This is the level where more elements of behavioural and environmental factors are operating. At this level, child survival is closely linked to the timing, spacing and number of births and to the reproductive health of mothers. Early, late, numerous and closely spaced pregnancies are unequivocal contributors to high infant and child mortality and morbidity rates, especially where health-care facilities are scarce. Where infant mortality remains high, couples often have more children than they otherwise would to ensure that a desired number survive.

Consequently, health requires commitment from community or societal levels (cared for by governments) and parental or familial levels. But how well do governments play their part is the more complex of the two. This argument can draw on the findings of Caldwell (1986) and how he identified two groups of health achievers. He employed a simplistic test for identifying superior health achievers where an infant mortality rank at least 25 places above the country's per capita income rank, and that for identifying poor health achievers one at least 25 places below the income rank. Interesting enough, oil producing countries (such as Oman, Saudi Arabia and Iran) which were classified among poor health achievers, have incomes 15 times greater than the superior health achievers but cannot equal the mortality levels of the latter. Successful stories were told by smaller lower income countries such as Sri Lanka, Costa Rica and Kerala state in India. Caldwell (1986) offers an alternative route to low mortality with the success of non-democratic countries such as China, Vietnam and Cuba in devoting large resources to the health sector.

Using three different definitions of wealth, a recent appraisal of Caldwell's 1986 superior and poor health achiever analysis shows a changing situation (Palmer, 1997). The latter study repeats Caldwell's analysis, first using identical methodology but updated with GNP per capita and infant mortality data for 1994. Two more methods are applied, substituting for GNP per capita, first 1994 purchasing power parity estimates of GDP per capita, and then average GNP per capita over the preceding ten years. Palmer's (1997) analysis showed strikingly that with the exception of Libya many of the Arab countries (Yemen included) disappeared from the group of under-achievers. These changes are perhaps most consistent with the social changes in the region. Changes in superior achiever countries were possibly related to the intensity and continuity of government investment in social programmes. Palmer (1997) also shows some evidence that the previous superior achievers do lose ground over time. Sub-Saharan Africa's economic "malaise" of the 1980s and early 1990s is reflected in its generally worsening infant mortality ranking (Palmer, 1997).

Caldwell's recipe based on experience from Sri Lanka, Costa Rica and Kerala state in India is: considerable female autonomy, considerable inputs into both health services and education and closing the gap between female education levels and those of their male counter-parts, health care accessibility to all-no matter how remote, poor those populations are, health care services working efficiently given popular pressure on them, providing a nutritional floor or distributing food in some kind of egalitarian fashion, achieving universal immunisation and concentrating on the period before and after birth (prenatal and postnatal health services) and having deliveries performed by persons fully trained for this purpose. Therefore, at *all* levels, identifying higher risk populations groups or higher risk individual behaviour aids the process of future actions to induce changes needed to nourish commitments to good health.

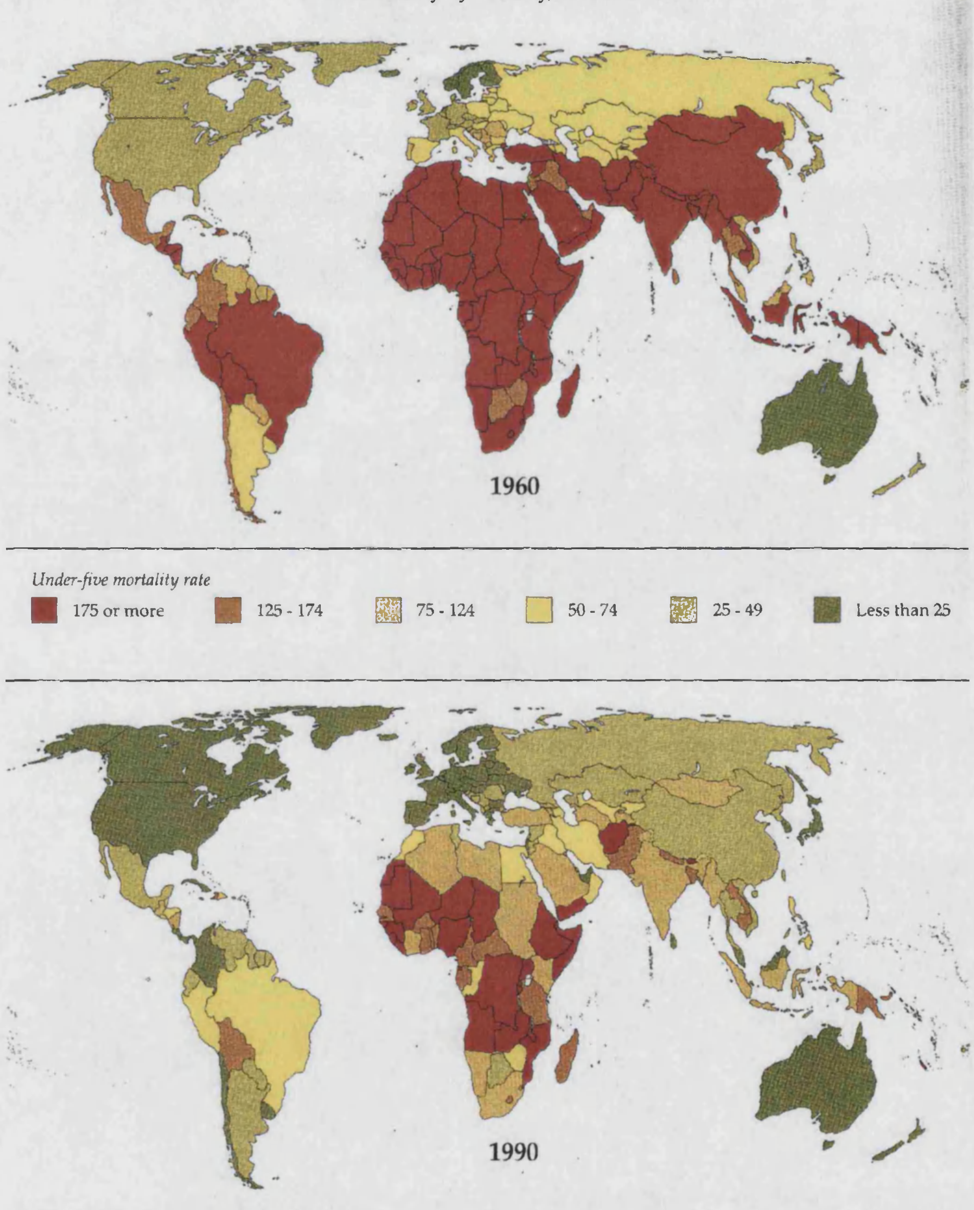
1.2 A Comparative Perspective

Three countries of the developing Arab world are the focus of this comparative study: Egypt, Sudan, and Yemen. The data sets available for this study come with their limitations and it will not be possible to have measures for all the above-mentioned factors. The motivation for this study is perhaps well-illustrated by Fig. 1.2 below. Remarkable progress has been made in reducing the mortality of young children in recent decades. Social and individual change, government intervention, and biomedical research have produced these gains.

Fig. 1.2: A *Global* Comparative Perspective of Child Mortality Transition

Child mortality has fallen sharply in the past thirty years, with particularly rapid declines in parts of Asia and Latin America.

Child mortality by country, 1960 and 1990



Source: Appendix A.

Source: World Development Report (1993), page 22.

Breakthrough periods are identified for each of the societies, when provision of health services was implemented on a large scale. Yet, much more remains to be done. In the 1960s close to two in five children born did not survive to their fifth birthday in the three settings. Three decades later, the situation is almost the same in Yemen, somewhat improved in Sudan and radically rectified in Egypt. Still, in the Arab region, the death of a child remains a common feature of the family-building process. This would result is a sizeable disparity between the number of children who are born and the number who survive to adulthood (Farid, 1984).

Most of the loss occurs early in life; communicable, and largely preventable, diseases are still common alongside other societal and economic hurdles causing serious lapses in the pace of mortality decline. Findings from the thesis will help explain the roles played by certain bio-demographic and socio-economic factors contributing to these lapses and reiterate on future policies to reform the situation.

These countries were represented and signed individual commitments to the Programme of Action of the International Conference on Population and Development (ICPD-Cairo, 1994). With regard to child health, the benchmark indicators for ICPD-Cairo (1994) were those adopted by the World Summit for Children, held in 1990, in New York. Then, a set of goals for children and development up to the year 2000 were agreed, including a reduction in infant and under-5 child mortality rates by one third, or to 50 and 70 per 1,000 live births, respectively, whichever is less. Further on and by 2005, countries with intermediate mortality levels should aim to achieve an infant mortality rate below 50 deaths per 1,000 and an under-5 mortality rate below 60 deaths per 1,000 births. By 2015, all countries should aim to achieve an infant mortality rate below 35 per 1,000 live births and an under-5 mortality rate below 45 per 1,000. The key message was when countries achieve these levels earlier, they should strive to lower them further.

These goals were based on the accomplishments of child-survival programmes during the 1980s, which demonstrated that available effective low-cost technologies could be delivered efficiently to large populations. However, the morbidity and mortality reductions achieved through extraordinary measures in the 1980s are in danger of being eroded if the broad-based health-delivery systems established during the decade are not institutionalised and sustained (ICPD-Cairo, 1994).

The document further suggested a number of public health activities to achieve these objectives, superseded by a call to all Governments to assess the underlying causes of high child mortality. The latter process crucially calls for fair quality and country-representative child mortality data.

1.3 Availability of Health and Demographic Data:

Many countries have inherited well-founded vital registration systems (such as the Sudan and Egypt) for recording mortality and fertility data, but the consistency, quality and maintenance of these system remain questionable. Such a deficiency prompted governments to the need for representative sample surveys from which estimates about the whole population maybe made. These sample surveys will remain cost-effective in many parts of the developing world given the persisting challenges and difficulties of maintaining longitudinal data collection systems such as vital registration.

Many developments have taken place in recent years to improve on this tool of data collection together with recent advances in statistical methodologies. This is clearly visible through extra modification and additions as one observes the transition from World Fertility Surveys (WFS) to the Demographic and Health Surveys (DHS). The successful legacy of the DHS programme carried out on behalf of USAID since 1984 by Macro International in more than 60 developing countries, transcended to the maternal and health surveys sponsored by the League of Arab States' PAP-CHILD (Pan Arab Project for Child Development) programme plus its Gulf Family Health Survey (GFHS) - together in over 15 countries since 1989. These survey programmes have yielded a comprehensive research repository dealing with population health- and policy-related issues.

The following sections provide background information for the three countries' history, geography, economy, demography and population policy. Country-specific sections will further trace the changes in child mortality relative to three time points- WFS, DHS, and the PAP-CHILD surveys. The choice of countries is by no means unique yet it allows for an in-depth comparison between localities, given the similarities in cultural and to some extent environmental settings and considerable contrasts given child health and demographic measures. In a number of demographic and health studies, Sudan has been considered as a sub-Saharan country exhibiting comparative figures to those found in the region.

1.4 Background on Egypt

Egypt is one of the most influential countries of the Middle East and North Africa given both its cultural and historical importance. It covers an area of approximately 1,001,450 sq km (386,662 sq miles) in north-eastern Africa, its northern coastline along the Mediterranean Sea, its eastern coastline along the Red Sea and touching the State of Israel in the Sinai. Libya shares its western border, Sudan its southern border.

Egypt is overwhelmingly a desert country bisected by the River Nile. Over 90 per cent of the land area is formed by a convergence of deserts -- the Libyan Desert to the west, the Sahara and Nubian Deserts to the south and the Arabian Desert to the east. There are oases scattered across this wasteland and a swathe of land along the Suez Canal which is cultivated, but it is mainly the land fed by the River Nile -- the Nile valley and the Nile Delta --that is both habitable and arable. The Sinai Peninsula is formed of sand desert and spectacular mountains rising as high as 2,637 meter (8,652 feet) above Red Sea level.

To attempt a summary of Egyptian history would require volumes of text to be written, but a brief outline of historical Egypt can be described by the following periods (Vatikiotis, 1991). In the Pre-dynastic history (25,000 BC), Egypt encompassed a multiplicity of settlements, which gradually became small tribal kingdoms. The two kingdoms vied for power over all the land of Egypt. This struggle led to the victory of the south and the unification of the Two Lands in 3100 BC under the command of Menes who is also known as Narmer. This was the beginning of the dynastic period of the Pharaohs. The Pharaohs reigned the region until the Thirtieth and final Pharaonic dynasty was overthrown by Artaxerxes III, remaining under Persian domination until the arrival of Alexander the Great in 332BC.

A series of invasions by foreign conquerors - Hyksos, Persians, Greeks, and Romans – has presumably affected the Egyptianity. Three epoch-making events in its history, however, underlie the emergence and development of modern Egypt: the Arabic-Islamic conquest in the seventh century; the non-Arab Islamic conquests from the twelfth to the sixteenth centuries, namely Kurdish, Turkish and Ottoman; the European encroachments beginning with the Napoleonic expedition to Egypt in 1798. The legacies that these influences have left in Egypt in the areas of social and cultural changes and adjustments constitute perhaps the essential and crucial element of development. The Arab invasion marked a turning point in Egypt's history, for it introduced two original factors in her future development: a new religion and a different language. For three centuries (1250-1520), Egypt was the centre of cultural and intellectual activity in the Arabic-speaking part of the Islamic world. Muhammad Ali reigned in Egypt from 1805-1848 a period characterised by continuous efforts to reform the administration and develop agriculture, irrigation, public works and industry – in general, he insisted upon the massive introduction of European technology in all the activities and functions of the State. Muhammad Ali's rule was a tremendous impetus for the emergence of modern Egypt (Vatikiotis, 1991).

The British occupation of Egypt extended between 1882-1952, a period characterized by a triangular power struggle between the British, the King (The Turkish ruler) and the nationalist Wafd party, which had the support of the population. When parliamentary elections were held in 1952 the Wafd Party won the majority of seats and Nahas Pasha as prime minister repealed the 1936 treaty which gave Britain the right to control the Suez Canal. King Farouk dismissed the Prime Minister, igniting anti-British riots which were put down by the army. This event compelled a secret group of army officers, which became known as the Free Officers, to stage a coup d'etat and seize control of the government. King Farouk was forced to abdicate and General Naguib - as the most senior officer, the nominal leader of the group -- became Prime Minister and commander of the armed forces.

In 1953 the Egyptian Arab Republic was declared under the rule of the Revolutionary Command Council (RCC). Gamal Abd Al-Nasser became acting head of state and in 1956 officially assumed the presidency of the republic until he passed away in 1970. Anwar Sadat followed Nasser and his rule (1970-1981) was characterised by the liberalization of the Egyptian system. After his assassination in 1981, vice-president Hosni Mubarak assumed the presidency till the present time.

Although modern day Egyptians are usually grouped together with "the Arabs" due to their language and Islamic traditions, this is not completely accurate. There is a truly Bedouin Arab grouping within Egypt, the majority still nomadic tribal peoples living in isolated oases and roaming through the country's vast desert regions. Many Bedouin Arabs are settled in the Sinai Peninsula and along the Red Sea coast, across from Arabia.

The third main racial grouping in Egypt is comprised of the Nubian peoples who lived for thousands of years in their own land along the Nile, called Nuba, which overlapped from Upper Egypt into northern Sudan. Most of Nuba was flooded in the time of Gamal Abdel Nasser with the construction of the Aswan high dam and the creation of the artificial Lake Nasser. The Nubians were resettled by the government but much of their ancient culture and stunning architectural tradition has been lost.

The separation between Lower and Upper Egypt is also of great historical significance. Upper Egypt narrow and within immediate contact with the desert, was limited in its outlook towards Africa. The tombs and temples at Luxor, Aswan and Edfou are some of the most prominent finds in retracing of ancient Egyptian history. The sand and dry climate preserved these monuments for thousands of years. Lower Egypt on the other hand occupied the wide Nile delta richly agricultural, marshy and intensively habitable. Facing outwards to Asia, Europe and the Mediterranean, the Lower Egyptian must have been in commercial and other contact with various people: Hebrews, Phoenicians and Greeks. Little information is available about the interaction of these peoples in the Delta and about its cultural effects. This is perhaps due to the continuous destructiveness of the muddy, flooded earth of the delta through the centuries (Vatikiotis, 1991).

The inhabitants of rural Egypt have until recently been poor, sick and on the whole unattuned to the requirements of modern life. Their poverty derived from a peculiar agricultural-economic structure, their sickness, especially in the form of Bilharzias and anklostoma, came with the perennial irrigation introduced by Muhammad Ali in the nineteenth century (Vatikiotis, 1991). For a half century the rural population has shifted to the main urban centres in search of employment (Vatikiotis, 1991).

Islam is constitutionally established as the official religion of Egypt and around 90 per cent of the population are Sunni Muslim with a small minority of Bohra Muslims and other non-Sunni sects represented. Coptic Christians form the country's largest and most significant religious minority with the Coptic Church estimates placing their number at around 7 million. The Copts share the same racial background as their indigenous Muslim countrymen and remain wedded to their ancient Christian beliefs and traditions. Another one million or so Roman Catholics, Greek and Armenian Orthodox Christians as well as Protestants are also among Egypt's citizens.

i. Egypt's Economy

During the presidency of Gamal Abdel Nasser, the economy of Egypt was radically socialized. Beginning in 1961, foreign trade, banking, insurance, and most wholesale and industrial establishments were nationalized. Those sectors which remained in private hands were placed under heavy regulatory restraints. Industry was expanded and production increased according to a five-year plan. Inadequate foreign investment due to reduction in trade with capitalist economies, a sluggish bureaucracy and the disastrous 1967 Arab-Israeli War subverted subsequent development programmes until a process of economic reform was inaugurated by Abdel Nasser's successor, Anwar Sadat, in the aftermath of the October War of 1973 (Vatikiotis, 1991).

By reversing many of Abdel Nasser's policies and opening Egypt to foreign investment, Sadat began a gradual revival of the Egyptian economy which was significantly enhanced by remittances from Egyptians working in the surrounding oil producing countries. The very slow but sure relaxation of import, currency and trade restrictions stimulated Egypt's foreign exchange economy.

Tourism, which had fallen off drastically during Abdel Nasser's time due to Egypt's anti-western stance and poor tourist infrastructure, was restarted with the privatisation of many nationalized tourist facilities. Sadat's dramatic peace initiative and treaty with Israel transformed the western view of the Arab leader and his country and further enhanced the country internationally.

In the early twentieth century, a limited manufacturing sector was developed to cater to domestic demands. The Second World War stimulated industrial growth and the beginnings of a major textile industry. The socialist government of Abdel Nasser emphasized industrial development and established an industrial base which continues to expand. Cairo, Alexandria, Helwan and the new industrial cities outside Cairo are modern Egypt's main industrial areas, producing iron and steel, textiles, refined petroleum, plastics, building materials, electronic products, paper, automobiles and chemicals. Apart from textiles, most industrial products are made for local consumption. Fishing is another important and growing industry in Egypt centred in the Red Sea and the Mediterranean. Egypt's most valuable mineral resource is oil, although the country also has gold deposits as well as iron ore, manganese, phosphates and uranium.

Despite the many advances the country has witnessed under President Mubarak, Egypt continues to suffer from the vagaries of regional instability and its exploding population. Government leaders openly admit that population growth is undermining all efforts toward developing the country's economy. This situation is further aggravated by consumerism. Servicing a foreign debt over twice the size of the national budget is another negative factor. Under pressure from the IMF and World Bank, Egypt finally began to lift price controls, reduce subsidies and begin to relax restrictions on trade and investment (Jankowski, 2000).

Since the 1980s, the government has actively pursued an economic liberalisation programme with an emphasis on increased private section participation. The annual gross domestic product (GDP) increased from U.S. $6,598 million in 1970 to $35,784 million in 1993 (World Bank, 1995). The annual growth rate in the GDP was estimated to be 9.5 percent for the period 1970-80, and 4.3 percent for the period 1980-93. The average annual inflation for the period 1980-93 was 13.6 percent. In 1960, agriculture represented 40 percent of the GDP. Since then, agriculture's share has fallen steadily. The agricultural sector now contributes less than 20 percent of the GDP while the industrial sector has expanded from 15 percent in the 1960 to 22 percent in 1993 (World Bank, 1995). The Egyptian government has adopted a policy of land reclamation and fostering of new settlements in the desert.

Although the economic and social situation has improved steadily over time, Egypt is currently ranked at 112 out of 174, in the Medium group of the Human Development Index (UNDP, 2000) compared to 107 out of 174 in 1995 (UNDP, 1995). It is also classified as a low-income economy (World Bank, 2000)

Unemployment looms as a crucial challenge to the Egyptian economy. Solving the employment problem through growth is critical not only for the economy, but also for social stability. Current official estimates place unemployment at 8 percent, and the labour force is growing at around 3 percent annually. Egypt will need to achieve a sustained real GDP growth rate of at least 6 percent annually for unemployment to decline to more manageable levels (World Bank, 2000).

Another challenge is tourism, which represents one of the most lucrative sectors of Egypt's economy but is highly vulnerable to internal violence and regional politics. The government remains hopeful that the oil and gas discoveries in the western desert will produce significant revenues (World Bank, 2000).

ii. Summary Demography of Egypt

The population of Egypt, excluding persons who are living abroad, is estimated to have been 60,236,000 in January 1996 (CAPMAS, 1996). Fertility levels were high prior to World War II and then declined gradually following the war. By 1972, the crude birth rate (CBR) was 34.5 births per 1000 population. At that point, the CBR began to rise again peaking at 39.8 birth per thousand in 1985. By 1994, and resuming its decline, the CBR level was 28.6 per thousand population (CAPMAS, 1995) .

Mortality levels were high prior to World War II, after that the crude death rate (CDR) dropped from a level of 30 deaths per thousand population in the 1940s to around 17 per thousand population in 1960. Much of the reduction in the CDR was owed to a sharp decline in the number of deaths in early childhood. Infant mortality levels decreased rapidly after the war, falling from a rate of 200 deaths per thousand live births in the 1940s to 124 deaths per thousand live births in the late 1970s (Bucht and El-Badry, 1986). Further declines were sustained in the 1980s and by 1994 the CDR reached 6.8 deaths per thousand live births (CAPMAS, 1995). The reduction in mortality was reflected also in an increase in life expectancy which has risen to 64.8 years for females and 62.4 years for males by 1992 (UNDP, 1995).

Although the population growth rate has gone down slightly (from 2.8 percent annually in the 1980s down to 1.91 percent in 1996), the country's population explosion is its greatest and most intractable problem, exacerbated by the sheer lack of habitable land area (CAPMAS, 1996). Almost the entire population lives in the Delta and in the Nile Valley which is only about 4 percent of the country's land area, making this land among of the most densely populated in the world. Until today nearly half the population reside in overcrowded cities. To remedy this, the Egyptian government has inaugurated a series of incentives to try and lure many Egyptians away from Cairo and Alexandria. Part of this programme includes the construction of industrial cities located well outside the main centres and the programme seems to be meeting with a measure of success.

A series of demographic and health surveys had been and continue to be conducted in Egypt. Amongst those are Egypt's Fertility Survey, (EFS, 1980) , Egypt's first Demographic and Health Survey, (EDHS-I, 1989/90), Egypt's Maternal and Child Health Survey-PAP-CHILD, (EMCH, 1991), Egypt's second EDHS-II (1992) and Egypt's third EDHS-III (1995), respectively.

iii. Egypt's Population Policy

After the 1952 revolution, the top leaders of the new government were increasingly concerned with the rapid population growth, which was seen as hindering efforts to raise the living standard of the Egyptian people. By 1966, Egypt has established a national family planning programme, which aimed primarily at reducing fertility and thus, population growth. The first national population policy was introduced in 1973 and in 1975 it was further articulated to recognize the simultaneous importance of the four inter-related dimensions of Egypt's population problems: growth, spatial distribution, characteristics and structure. A second population policy was issued in 1980, which placed greater emphasis on face-to-face communication and community-based activities to promote family planning. Following a national population conference in 1984, the National Population Council (NPC) was established with a primary role to co-ordinate efforts into four major areas: family planning, child welfare, women's participation in the Labour force and literacy. The third and current national population policy was formulated and adopted in 1986, emphasising the seriousness of population problems and the interaction between population and development.

The 1986 policy recognised seven principles necessary for the achievement of its basic objectives:

1. Each family has the right to decide on the appropriate number of children to have and to obtain information about the means to enable them to achieve their decision with the framework religion, Egypt's civilisation and the values of its society;
2. The avoidance of the use of abortion or sterilization as a means of family planning;
3. Recognition of the citizen's right to migrate and to move from place to place within Egypt and abroad;
4. Adoption of a positive incentive system based on increased awareness of the role of the individual and the community and the avoidance of any methods of coercion, negative incentives or punitive methods;
5. Educational, cultural and health development of the individuals to help them to become a source of productive energy;
6. Local government bodies are considered the basis of implementation of all programmes;
7. Encouragement of voluntary efforts and community participation in the solution of the problem.

In 1991, the NPC introduced a population strategy with the following targets:

8. To reduce the CBR to 27 per thousand population in the year 1997 and 26 per thousand in 2002 leading to growth rate in the years 1997 and 2002 of 2.0 percent and 1.9 percent, respectively.
9. The total fertility rate (TFR) will be reduced to 3.5 in 1997 and 3.1 in 2002.
10. Current contraceptive prevalence will increase to 55 percent and 59 percent in the year 1997 and 2002, respectively. **(EDHS-II, 1992)**

Following the International Conference on Population and Development (ICPD-Cairo, 1994), a modified population strategy was developed placing greater emphasis on providing reproductive health services and supporting non-governmental organizations in the development of local communities. At the same time, the NPC developed a proposal for a new population policy building on the positive aspects of the ICPD- Cairo (1994) plan of action.

In January 1996, a new population sector was created in the Ministry of Health, which is renamed the Ministry of Health and Population (MOHP) which replaced the old Ministry of Population and Family Planning. The MOHP has a nation-wide network of more than 3,700 primary, secondary and tertiary health care facilities through which maternal and child health services are provided. It continues to stress the integration of family planning and MCH programmes.

To reflect changes in child mortality levels in Egypt, the following sections draw on the findings of child mortality investigations based on EFS (1980), EDHS-I (1988/89) and EMCHS (1991), respectively.

1.4.1 Differentials of Early Childhood Mortality –from WFS to DHS

Drawing on results from EFS (1980), many interesting findings emerge; Eid and Casterline (1988) showed how, despite substantial decline in infant and child mortality in Egypt in the three decades before EFS (1980), rates remain high. The EFS (1980), estimates for the latter half of the 1970s indicate that roughly one out of eight children died in the first year of life and roughly one out of five in the first five years of life. The rates were even higher in the rural areas, where a majority of the births occurred (one quarter of children died before age 5 years which further increases to one third in some parts of Upper Egypt).

Eid and Casterline (1988) and Callum and Cleland (1988) identified a strong correlation between short birth intervals (less than 2 years) and higher risks of mortality for the index births. Conversely, Callum, Farid, and Moussa (1988) investigated the impact of infant and child mortality on birth spacing and on ultimate parity. They observed that an infant death was shown to be associated with a reduction of about six months, roughly 15-20 percent, in the interval to the next birth. A significant reduction in interval length associated with an infant death was observed among users and non-users of contraception, though it was more pronounced among the former.

One further observation from the analysis of EFS (1980) data is the issue of under-reporting of female deaths. Ahmed (1990), using official census and survey data from 1976 and 1980, analysed and compared trends in sex differences in child mortality in Egypt.

Ahmed (1990) concluded that males have higher mortality (levels) in infancy, but females have higher mortality from birth to ages 5, 10, 15 and 20. The higher the social class (indicated by mother's education) the higher the mortality level of boys relative to girls. The main factor that causes sex difference in child mortality is the inequality in illness treatment favouring male children (Ahmed, 1990).

Makinson (1986) investigated factors contributing to excess female infant and child mortality in Egypt with a multivariate analysis of EFS (1980), the Mosley-Chen (1984) child survival framework, and data from the 1978 Egyptian National Nutrition Survey. She concluded that parental son preference, and excess female child mortality, were not due to parental calculations of the economic or old-age security value of children. Evidence was found that Egyptian women are socialized into the belief that social status and marital security depend on the birth and survival of male children and that males should be given preferential treatment.

Given socio-economic correlates, Ismail, Casterline, and Cooksey (1988) reported the lack of association between household income and infant mortality and the weak association of the former with child mortality. Maternal schooling shows modest effects at best on infant and child mortality. Eid and Casterline (1988) also investigated the association of parental education status and the probability of survival of their children only to find it rather weak.

Conventionally, Egypt is sub-divided into 5 regions- Urban Governates, Urban Lower Egypt, Rural Lower Egypt, Urban Upper Egypt and finally Rural Upper Egypt. Using EFS (1980), Casterline, Cooksey, and Ismail (1992) re-examined determinants of infant and child mortality in rural Egypt, primarily the effects of household economic status and the availability of health services. They concluded that certain features of the health service environment affect survival in the neonatal period. In early childhood, survival chances improve markedly as income increases and if the household depends almost exclusively on employment income. In their interesting analysis of infant and child mortality in rural Egypt, derived from data collected as part of EFS (1980), Casterline, Cooksey, and Ismail (1992) specifically noted the significant differentials in neonatal and post-neonatal mortality which existed between Lower and Upper Egypt. The differentials could not be explained in terms of socio-economic variables, the household sanitary environment, maternal risk factors or medical institutions and personnel.

In infancy and in early childhood, mortality is strongly associated with region of residence and maternal demographic characteristics, and is weakly associated with parental schooling. Conversely, it was suggested that they could be attributed to fundamental though unidentified cultural differences between the two regions.

Only "region of residence", among the socio-economic factors considered, shows consistent and interpretable effects. In this respect, Egypt resembles Sudan, where regional differentials in childhood mortality are marked and apparently not explained by regional variations in the most readily measured socio-economic variables (Farah and Preston, 1982). Farah and Preston (1982) speculate that the disease environment chiefly accounts for the regional variation in Sudan, and this factor may also contribute to regional variation in Egypt. A related factor is the climate, with Upper Egypt characterised by much more severe seasonal variation in temperature than the rest of the country. Ismail, Casterline, and Cooksey (1988) speculate that regional variation could also be attributed to cultural factors, namely the stronger persistence in Upper Egypt of practices which detrimentally affect the health of the mother and child during pregnancy and the first half of infancy.

1.4.2 Differentials of Early Childhood Mortality – from DHS to PAP-CHILD

EDHS-I (1989/90) is Egypt's first Demographic and Health Survey. Sayed et al. (1989), using EDHS-I (1989/90), reported lower infant and child mortality estimates for the period 1984-88, 102 deaths per thousand live births compared with 1974-78, 203 deaths per thousand live births. They further emphasize the regional differential with rural mortality estimated as twice urban mortality, and with Upper Egyptian children at the highest risk.

Sayed et al. (1989) also report a decline in Egyptian fertility levels by 15 percent from the beginning of the decade (5.2 versus 4.4 births / woman). They observed large differentials in fertility by residence. For 1986-88, urban women averaged 3.5 births per woman and rural women average 5.4 births per woman, respectively. Rural Upper Egypt women had a higher average of 6 children, due to low use of family planning in the region.

Increased mean levels of post-neonatal mortality have been widely reported in the progeny of consanguineous marriages due to the expression of detrimental recessive genes, especially in the first year of life (Bittles et al. , 1991), and marriages between close relatives were reported at high frequency in the EDHS-I (1989/90) (Bittles, 1993). EDHS-I (1989/90) also showed substantially higher mean levels of consanguinity in rural Upper than in rural Lower Egypt, with 39.6 percent versus 28.6 percent first cousin marriages respectively in the two areas (Bittles, 1993) and significant excess neonatal and early infant deaths in the first cousin progeny.

One further observation from EDHS-I (1989/90) is that mortality estimates for the 10-year period preceding the survey is the sex difference in the infant mortality rate and child mortality rate, respectively. Choe et al., (1998) investigation assert that the magnitude of the sex difference depends on the sex composition of older siblings; specifically girls who have older brothers but no sisters have lower mortality rates than those with older sisters. They also suggest that the small amount of extra care provided to more valued male children results in their lower mortality.

Using the same data set, Timæus, Harris, and Fairbairn (1998) investigated the existence of any regional patterns in sex differentials in the use of certain preventive and curative health services – Egypt showed a weaker pattern in the use of health services favouring male over female children. However their analysis shows an "intra-rural" sex differential, favouring boys, in the utilisation of health services and early response to diarrhoeal episodes.

Moving to Egypt's PAP-CHILD (EMCH, 1991), the survey estimates reveal that for both fertility and mortality declines there seems to be an inverse association between the pace and size of the declines and the degree of modernisation in each of these five regions.

In summary, Egypt has been showing a major child survival success story in the past two decades-the pace of child mortality decline has been faster than infant mortality decline and notably accelerated since the mid 1980s (National Child Survival Programme began in 1984). Yet, Egypt exhibits a strong differential in almost all demographic measures by region of residence. Rural Upper Egypt remains at a disadvantage with high under-5 mortality (89 per thousand as compared to 34 per thousand birth in Urban Governates); likewise the TFR remain as high as 6.7 as compared to that of the Urban Governates at 2.9. Similar shortfalls are also observed when considering other health indicators such as full-immunisation for children 12-23 months old, 64 percent for Upper Rural as compared to 87 percent in Urban Governates and the percentage of ever-using a contraceptive method, 34 percent in Upper Rural as compared to 84 percent reported by Urban Governates women (almost none began to use contraceptives immediately after marriage).

In the period 1971-76 women in Egypt had an average of 6 births. In the early 1990s this figure reduced to 3.9 births per woman. The largest and most sizeable decline has been in adolescent fertility since the mid-1970s. Egypt is a country where knowledge of family planning is universal- the proportion of ever-married women knowing any method increased from 90 percent in 1980 to 99.6 percent in 1991, (EDHS-II, 1992). This has aided the emergence of a new reproduction pattern with earlier completion of childbearing with formation of "smaller" urban/literate families and moderate levels of fertility among illiterate women living in urban areas (EMCH, 1991).

Table 1.4 below summarises the changing rates in Total Fertility Rates (TFR) and childhood mortality for the last three decades. The pace of decline of fertility and child mortality appears to have slowed down by the estimates of the early to mid-90s.

Table 1.4: Summary of TFR, IMR and Under-5 estimated from Egypt's WFS and DHS

Egypt		Child Mortality	
	Total Fertility Rate (per woman)	Infant Mortality Rate (deaths / 1000 births)	Rate of Death under age 5 (deaths / 1000 births)
EFS-1980	5.3	134	197
EDHS-1988/89	4.4	73	102
EMCHS-1991/92	4.1	59	82
EDHS-1992/93	3.9	62	85
EDHS-1995	3.6	63	81

--Estimates based on the 5-years preceding the survey.

1.5 Background on The Republic of the Sudan:

The Sudan is Africa's largest country (approximately 1 million square miles in area) bordered on the north by Egypt, on the east by Ethiopia and the Red Sea, on the south by Uganda, Kenya and Zaire and on the west by Chad, the Central African Republic and Libya. Sudan is a land of rich ecological contrasts, stretching from desert areas in the North through savannah areas to dense equatorial jungle in the South. According to the 1955/56 census, 597 tribes were found in the Sudan speaking some 115 languages. Aridity in the North and swamps in the South halted the development of these areas and fostered nomadism; population concentration is greatest in the middle belt and particularly along the Nile and its tributaries. Located in the heart of Africa, Sudan's population is diverse; influenced both by

Arab and African indigenous tribes- the northern portion are Arabs comprising about 55 percent of the population and the southern portion are blacks (African-origin) making-up the rest of the population (45 percent). The heart of the country, in terms of population, lies at the confluence of the Blue and White Niles. The complex of the "Three Towns", comprising the three largest cities, namely Khartoum, Khartoum North and Omdurman, is situated there and contains almost 20 percent of the population (Holt and Daly, 2000).

Historically, the Egyptian influence on this region probably began during Egypt's Old Kingdom, about 2755-2255BC, when the country was known as Nubia. In AD350, an invasion by the Christian Axumite Kingdom of Ethiopia resulted in the conversion of most of the population to Christianity, and by the 6th century AD three separate Christian kingdoms were well established. From the 16th century AD onwards, Turkish influence grew stronger under the Ottomans, and Islam gained a firm hold as the most popular religion. In 1822, Egypt, itself a province of the Ottoman Empire, won a great victory against Nubia and Nubia once again became an Egyptian province, known as Egyptian Sudan. In 1822, Muhammad Ali founded Khartoum at the confluence of the two (the White and the Blue) Niles, and by 1830 the first Egyptian governor of the Sudan was extended there (Holt and Daly, 2000).

Egypt's power over the Sudan held fast for more than half a century. With the opening of the Suez Canal in 1869, however, European interest in the region was growing, particularly from Britain and France. The Suez Canal project had proved very expensive, and as a result Egypt found itself heavily in debt to these foreign powers. Internal unrest triggered by the slave trade mounted steadily during this period, and foreign intervention was inevitable.

The Mahdist Revolt began in 1880 and resulted in the capture of Khartoum in 1885, with a complete victory over the Egyptian army. In September 1898, Kitchener's forces overwhelmingly defeated the caliph at Omdurman, and as a result the Mahdist movement collapsed completely. In 1899, the Egyptian and British governments signed an agreement, making provision for their joint sovereignty in Sudan. This was known as the Anglo-Egyptian Condominium Agreement. British control of the Sudan remained in place until 1950, despite growing demands by the Egyptians for British withdrawal. In 1953, the two governments signed an agreement allowing a three-year transitional period leading to total Sudanese independence. The first Sudanese elections were held late in 1953 and the first all-Sudanese government took office in 1954 and with it, the Republic of the Sudan was born.

Soon after gaining independence (in early 1956), problems began for the new republic almost immediately. The population of Sudan is characterised by two distinct cultural traditions, one in the North and one in the South. Northern Sudan consists of six regions: Khartoum, the national capital, Northern region, Eastern region, Central region, Kordofan and Darfur. The majority of people in northern Sudan are Muslims, although there are some Christians and practitioners of traditional religion. Arabic is commonly spoken in the North in addition to local languages. Southern Sudan, consists of three regions: Equatoria, Upper Nile and Bahr El Ghazal. The majority of the people in the Southern region are Christians or practising traditional religion and speak local African indigenous languages. In general, they are more closely linked to population groups further south than those to the north.

Given vast cultural differences between these two regions (Arab and Muslim culture in the north, African indigenous beliefs in the south) problems escalated rapidly, and civil war was imminent. Sudan consequently endured a civil war that has spanned more than three decades. Conflict characterised the ruling times of the parliamentary and military government of Major-General Ibrahim Abboud (1956-1969), the era of Jaafar Nimeiri (1969-1985), the Transitional Government and the Third Parliamentary Regime (1986-1989), and the currently ruling the Revolutionary Command Council for National Salvation (RCCNS). The RCCNS showed strong alliance with the National Islamic Front (NIF). The NIF regime comported essentially with its predecessors, military and civilian, in seeing the south as an integral part of the Sudan, and in seeing itself bound to a ' civilising mission' of islamisation (Holt and Daly, 2000). The main opposition are the Sudan Peoples' Liberation Movement / Army (SPLM / SPLA). And while the mainstream SPLM continued to espouse a united – democratic and secular – Sudan, the Nassir group and others reflected more accurately southerners' aspiration for independence from the Arab Muslim World.

By the late 1990s the outcome of the civil war remained in doubt. That is the decade of NIF rule in many ways followed that patterns set since independence and gave little hope for political settlement and no reason for expecting a military solution.

From a global perspective the seeming impossibility of lasting and effective co-operation between a southern rebel organisation – even one that had proven as sophisticated and determined as the SPLM / SPLA – and northern-based parties – even when facing their own destruction at the hands of the NIF – portrays the fundamental weakness of the Sudanese state (Holt and Daly, 2000). The involvement of neighbouring states in the civil war was a feature of the Sudan's chaotic foreign relations under the NIF regime. Given the ideological character of the Government, and the opposition this engendered at home and abroad, these were more than ever inextricable from both domestic politics and the Sudan's sorry economic state (Holt and Daly, 2000). Since 1997, the Sudan People's Liberation Army (SPLA) has controlled much of the south. More recently, the southern-based rebels and the government have conducted direct negotiations under the auspices of the Inter-Governmental Authority on Development (IGAD).

i. Sudan 's Economy

Sudan's economy is mostly agricultural and pastoral, with about 65 percent of its population making their living through crop growing or animal grazing. Lack of irrigation schemes and poor general infrastructure, however, mean that the full potential of the land is not being exploited. Indeed, only about 5 percent of the Sudan's land area is used for farming.

Principal food crops consist of millet, sorghum, rice, cassava, wheat, peanuts, beans and bananas. The main export crops are sorghum and cotton. The latter is produced in the Gezira (al-Jazirah) region, between the Blue and the White Nile. In the south, agricultural activity is mainly pastoral, with the main domestic livestock being cattle. Sheep, goats, camels and chickens are also reared. There is some fishing along rivers and coastline. Forestry activities include the production of gum Arabic, (an ingredient in sweets, perfumes and processed food) beeswax, tannin, senna and timber, principally mahogany (Holt and Daly, 2000).

The Sudan is a potentially wealthy country, with rich reserves of oil and minerals. Yet these reserves are barely exploited, with industry contributing as little as 4 percent to the total national economy. Oil and natural gas reserves have been discovered in western areas, but, as yet, only small amounts have been mined and refined. Other minerals to be found in the Sudan are mica, marble, chromite, gypsum, iron ore, uranium, manganese, zinc and copper. Gold has also been found in the Red Sea Hills but, again, little of these riches are mined or processed. Some manufacturing industries exist, but these are in a very early stage of development. These mostly consist of the processing of agricultural products, but there is also some industry associated with textiles, paper, footwear and cigarettes. Sugar and petroleum refineries have also been established (Holt and Daly, 2000).

Unsurprisingly, the tourist industry is almost non-existent. The crippling cost of the continuing war has resulted in poor economic conditions, and the dangers inherent in travelling in certain areas mean that the Sudan is a far from popular place to visit. The latest UN figures record that only 52,000 visitors entered the country in 1987. Today's figures would probably be lower even than this (World Bank, 2000).

Because of the civil war, the country continues to experience widespread unrest with resulting destruction of the social infrastructure and disruption of the economy. Although the entire country has suffered the effects of civil war, the greatest impact has been in the South. This continues to hamper social and economic development. From the early 1990s onwards the Sudan experienced hyper-inflation and a persistent shortage of hard currency, with consequent shortage of essential goods and a resort to bartering, black-marketing and other devices by the hapless populion. Whereas the official rate of exchange had been about 15 Sudanese pounds to the US dollar in 1991, by the end of 1993 it was over 300 pounds, and by 1996 1,000 pounds. The regime continued to prosecute the war in the south, at a cost estimated at $1-3 million a day (Holt and Daly, 2000).

Sudan is ranked as a low Human Development Country with a rank of 157 out of 174 in Human Development Index (UNDP, 2000). Economic management is further undermined by the country's reliance on agriculture -- agricultural production accounted for about 48 percent of GDP in 1998 -- which is inherently vulnerable to climatic conditions and to fluctuations in international commodity prices (World Bank, 2000). Since 1996, GDP growth has averaged 5.5 percent led mainly by agriculture which accounts for an estimated 45 percent of GDP (World Bank, 2000).

Sudan is making progress in implementing a medium-term reform program monitored by the IMF. Growth has been revived, and exports are improving, but there are still severe constraints which stem from the erosion of basic infrastructure. Most recently, Sudan has benefited from a $2 billion private investment in oil production which is expected to reduce the country's import bill and improve the availability of foreign exchange for development financing (World Bank, 2000).

ii. Summary Demography of the Sudan

The first census, which was undertaken in 1955-56, reported a population of 10.3 million. The 1973 census reported 14.1 million and the 1983 census 20.6 million. In a period of 27 years, the population had doubled in size, with a fourfold increase in the urban area compared to less than doubling in rural areas. A projection by the Census Office estimated that the population of the Sudan in 1989 was 24.5 million (Population Census Office, 1991). The intercensal growth rate was 1.9 percent per annum for 1956-1973, 3.9 percent per annum for 1973-1983 and 2.7 percent per annum for 1956-1983 (Population Census Office, 1991). Because of the coverage problems in the South during the 1973 Census (outbreak of civil war), the growth rate based on the 1956-1983 census data is probably the most plausible (Population Census Office, 1991).

Adjusted[1] total fertility rates (TFR) show a reasonable decline in fertility for the period 1973-1983, i.e. a decline from an estimate of 7.1 in 1973 census, to 6.9 in Sudan Fertility Survey (SFS, 1979) to 6.8 in 1983 Census.

Indirect estimates of life expectancy at birth obtained from 1973 census data were 46 years for males, 50 years for females and 48 for both sexes. By 1983, these levels had risen to about 53 years for males, 55 for females and 54 for both sexes, attributable to reduced early life mortality. The trend does not appear to have continued during the period 1983-1988. Further demographic indicators of the country will be revisited in the comparative section 1.7.

iii. Sudan's Population Policy

Until recently, Sudan did not have an explicit population policy. The population growth and fertility are considered to be acceptable by the government, while mortality, spatial distribution, and significantly high immigration and emigration are not. Official focus centres largely upon improving the standard of living through attention to infant and maternal mortality, maternal-child care, and providing primary health care and basic social services. The status of women and a modified spatial distribution are other priority concerns of the government.

[1] Based on P/F ratio for age groups 20-24, 25-29 and 30-34

The Ministry of Health (MOH) is responsible for developing health policies and for providing health care delivery at the district level (within provinces) and co-ordination of the services of the non-governmental organisation. Priorities of the MOH, closest to a population health policy, correspond to those outlined by the World Summit for Children Goals (1990).

Family planning activities in the Sudan started in 1965 with the establishment of the Sudan Fertility Family Planning Association (SFPA), an affiliate of the International Planned Parenthood Federation (IPPF). In the beginning, family planning services were limited primarily to urban centres, despite the fact that about 80 percent of the population is rural. With increased acceptance of family planning on the part of Islamic leaders and with the introduction of primary health care, the Government has integrated family planning into the overall maternal and child health programme, as a means of reducing maternal morbidity and mortality. The main aim of the SFPA is to encourage women to space births so that they and their children increase their chances for survival. Another goal of the family planning programme is to reduce the high rate of natural population increase and to improve the health of mothers and their children under the age of five years.

In 1994, the first National Population Conference took place which was instrumental in supporting and outlining the first National Population Strategy (NPS). Out of NPS, the suggestion for the establishment of the National Population Council (NPC) was made and today the NPC co-ordinates population-related activities and assistance with national and international agencies. These are also the parties currently involved in drafting Sudan's national population policy.

Sudan's National Population Policy:

1. To reduce maternal mortality from 552 maternal deaths per one hundred thousand live births to 225 maternal deaths per one hundred thousand live births by the year 2002, respectively and further reduce that by 5 % by the year 2015 (reducing obstetric incidents, births spacing, treatment of infertility, treatment of reproduction illnesses, breast cancer and STD).
2. To reduce infant and under-five mortality by 50% of their prevalent figures by the year 2015 (reducing high risk pregnancies, encouragement of breast feeding practices, management of childhood illnesses, improvement of perinatal health services, increasing vaccination and immunisation and protection from ARI and malnourishment and strong emphasis on health education.
3. The provision of family planning services according to the Islamic laws and country regulations, averting teenage and closely spaced pregnancies. Increasing CPR from 10% to 30% by the year 2015, availability of services and methods enabling couples to make safe and reliable choices of contraception in line of planned parenthood.

4. Expand youth and adult education to promote the well-being of adolescents enhancing gender equality and equity as ell as responsible sexual behaviour, protecting them from within early marriage and unwanted pregnancy and sexually transmitted diseases
5. Mobilising national efforts through a comprehensive programme of implementation to emphasize the cultural aspects and to remove all existing reservations that are incompatible with the position of women in the society. To encourage and improve their economic participation promoting her rights to education, employment, marriage, reproduction and family planning.
6. To promote and achieve gender equality in a systematic and comprehensive manner and empower women's position in development, economic activity, education, health, science and technology, culture and population activities and protecting her choices in planned parenthood.
7. To reduce population growth rate to attune those to the needs of comprehensive development, improving standards of living.
8. To increase public awareness about the implications to development of population growth rates, to focus national interest and to emphasize demographic security against practices leading to environmental deterioration and retardation.
9. To achieve a balance of the geographical population distribution in line with local needs of development and urban development by reducing the rate of migration from rural to urban centres. Encouragement of rural development in local small-scale industries dependent on local resources especially in less-density population areas.

(NPC-Draft Copy)

Sudan is also recognised and supported by USAID as a country with a great need for a child survival strategy. The existing child survival activities include immunization, control of diarrhoeal diseases, nutrition, child spacing, malaria control, acute respiratory infections, and AIDS (Harvey and Louton, 1987).

As is the case for many developing countries, chronic deficiencies remain in Sudanese data systems that would normally provide information for monitoring population related indicators. Hence, monitoring and assessment of population dynamics will continue to rely on cross-sectional sample survey methods. The on-going state of civil unrest has restricted the representation of the southern states in sample surveys; these are the Sudan Fertility Survey (SFS, 1979); Sudan's first Demographic and Health Survey (SDHS-I, 1989/90) and Sudan's PAP-CHILD Survey, (SMCH, 1992/93). Results in this thesis and most contemporary studies of Sudanese data, are only representative of the population residing in the northern part of the country.

1.5.1 Differentials in Early Childhood Mortality – from WFS to DHS

For more than two decades, data have been collected only for the northern parts of the country. An important early study of child mortality in the Sudan, and before findings of the SFS (1979) emerged, was that by Farah and Preston (1982)[1]. Using Feeney's procedure (1980) to analyse proportions dead among children of women given a child-mortality schedule by mothers' age, they observed a lack of any decisive mortality trend over the 1955-73 period. Although their evidence was fragmentary, it suggested that mortality in Sudan has not improved at any rate near the pace that had come to be expected as normal in developing countries for that period.

Research into indicators of early childhood mortality in the Sudan became more prominent through two points in the time and a larger scale of data collection- from SFS (1979) and SDHS-I (1989/90). Results indicate that under-five mortality had fallen slowly during the period 1975-79 to 1985-90 from 143 to 123 deaths per thousand births (a decline of about 14 percent). Much of the decline appears to be due to improved survival after the first month of life. Neonatal mortality did not decline during the same period, but this may be an artefact of underreporting of neonatal deaths before 1985. Results from SDHS-I (1989/90) began to reveal a pattern of associations-the pace of childbearing has a powerful effect on the survival chances of Sudanese children. Under-five mortality is 2.7 times higher among children born after an interval of less than 2 years than among children born after an interval of four years or more.

1.5.2 Differentials of Early Childhood Mortality –from DHS to PAP-CHILD

As stated above, results from SDHS-I (1989/90) supported a conservative decline of 14-16 percent in under-five mortality over the decade from 1975-79 to 1985-92, far less than what would have been anticipated for a developing country given that period of time. This corresponds to an annual rate of decline of about 1.5 percent compared with 2.0 percent for Sub-Saharan Africa (SSA), 3.1 percent for Asia, 3.6 percent for the Middle East, and 4.0 percent for Latin America, according to a recent analysis of global trends in child mortality over the 1980-85 period (Hill and Pebley, 1989).

This absence of improvement is consistent with evidence of an increasing prevalence of malaria with the spread of irrigation in the past several decades. Judged by visits

1 They use two bodies of data, one is the census of 1973, from which a large sample of household records has been constructed. The second is the investigation of Khartoum conducted by the Changing African Family Program, under the direction of John C. Caldwell. One is thought of as a broad social and geographic coverage, while the other provides intensive investigation of certain factors believed to affect levels of mortality.

to health units, malaria is the most serious health problem in the Sudan[2], afflicting particularly the central and southern regions. Nowadays, Sudan suffers economic losses due to the high incidence of malaria -40 percent or more of patients seeking hospital care are infected with malaria, and the burden of the disease remains heavier on children than it is on adults (further highlighted in section 1.7).

Rates of childhood mortality vary markedly across regions of Sudan, with the Darfur and Eastern Regions experiencing the highest mortality levels and the Khartoum and Northern regions the lowest. Mothers' education and the length of the birth interval also play important roles in childhood survival.

For the decade between SFS (1979) and SDHS-I (1989/90) the TFR dropped from 6.0 per woman to 5.0. Women living in urban areas had lower fertility (TFR 4.1) than those in rural areas (TFR 5.6), and fertility was lower in the Khartoum and Northern regions than in other regions. SDHS-I (1989/90) shows that fertility in Sudan was lower than is typically in sub-Saharan Africa, but the desire for children remains strong; one in three women want a child in the next 2 years, 32 per cent would like to postpone the next birth for two or more years, 25 per cent of currently married women would like to have no more children while the remaining women are undecided.

Sudan's PAP-CHILD survey SMCH (1992/93) estimates show the pace of mortality decline as slow but consistent, in the early 1970s under-5 mortality was 147 per thousand live births and infant mortality was 82 per thousand. In the early 1990s these figures declined to 113 per thousand and 70 per thousand respectively.

Regional disparities in mortality are clear-cut; children in Darfur (in the western part of the country and the second mostly densely populated region after Khartoum) and the Eastern State (characterised by a heavier burden of illness and death) appear to be at a higher risk when compared to children residing in Khartoum and Kordofan States (western part of the country). Infant mortality rates respond positively to certain advantages of maternal education, pre-natal care and health care during delivery. Thus, there is a need to take a closer look at the status of children in the Sudan. Children suffer from a number of socio-economic and environmental disadvantages; economic disadvantage is readily reflected in the inadequate nutritional status (24 percent of children under the age of 5 remain

2 July 21, 1997 - Dr. Omar Zayid, Director of Sudan's National Administration for Malaria Control in Malaria Weekly.

moderately under weight while 11 percent are acutely underweight). Darfur stands out repeatedly as the region with the highest disadvantage. The incidence of diarrhoeal disease is rather serious in the Sudan, almost one third of the surviving children born in the five years before the survey had an episode of diarrhoea in the period 2 weeks before the survey time (peak incidences among children aged 6-11 months with average duration of 4 days) and an overall high prevalence of respiratory infections (urban 48 percent, rural 46 percent).

Given preventive health measures, figures for immunisation/ vaccination are quite encouraging with 65 percent of children aged 12-23 months having been fully immunised while 100 percent had received at least one dose of immunisation/vaccination. Also, 80 percent of women in Sudan's sample had knowledge about Oral Rehydration Therapy (ORT) and almost 75 percent have used it before. But a gap may still persist between knowledge and practice. Amongst children who experienced a diarrhoeal episode in the past 2 weeks, only 27 percent of mothers have actually used ORS (SDHS-I, 1989/90).

Table 1.5 below summarises the changing rates in the total fertility rate (TFR) and childhood mortality for the last three decades. For both measurements the decline appears entrapped, the average number of children a woman would have fell by one child in the decade between 1979 and 1989. The situation seems reinforcing, insufficient declines of childhood mortality underline the sustained level of higher fertility. More influenced by more exogenous factors, under-5 mortality remains high, perhaps more reflective of the demise of the country's socio-economic conditions.

Table 1.5: Summary of TFR, IMR and Under-5 estimated from Sudan's WFS and DHS

Sudan		**Child Mortality**	
	Total Fertility Rate (per woman)	**Infant Mortality Rate (deaths / 1000 births)**	**Mortality under age 5 (deaths / 1000 births)**
SFS* 1978/79	6.0	79	123
SDHS* 1989/90	5.0	70	147
SMCHS 1992/93*	4.6	70	113

* Estimate of five-years period prior to the survey date

1.6 Background on The Republic of Yemen

The Republic of Yemen is a newly-born Arab state in the Middle East, bordering the Arabian Sea, Gulf of Aden, and Red Sea, between Oman and Saudi Arabia. The history of Yemen stretches back over 3,000 years, and its unique culture is still in evidence today in the architecture of its towns and villages. From about 1000 BC this region of the Southern Arabian Peninsula was ruled by three successive civilisations -- Minean, Sabaean and Himyarite. By the first century BC, the Romans conquered the area.

Both Christianity and Judaism were introduced into Yemen by the 4th century AD. In the early part of this century Ethiopians occupied the region. By AD570, the Himyarites formed an alliance with the Persians and defeated the Ethiopian invaders. Islam was introduced into the region in about AD630 and Yemen was ruled by a series of Arab caliphs. Later in the seventh century the Umayyad and Abbasid caliphs moved their capital first to Damascus and later to Baghdad, thus diminishing Yemen's political status in the new Islamic Empire. A succession of governors of the region followed, with a number of dynasties struggling for supremacy. When the country became part of the Ottoman Empire in 1517, its real power was still in the hands of the Zaydi imams. The first period of rule by the Ottomans lasted for over a century, ending in 1636, when the Zaydi imams reasserted their supremacy (Bidwell, 1983).

The British conquered Aden in 1839 and it was then known as the Aden Protectorate. The British also made a series of treaties with local tribal rulers, in a move to colonise the entire area of southern Yemen. The British influence extended to Hadhramawt by the 1950s and a boundary line, known as the "violet line" was drawn between Turkish Arabia in the north and the South Arabian Protectorate of Great Britain, as it was then known. This line later formed the boundary between northern and southern Yemeni states in the 1960s. In 1849 the Turks returned to Yemen and their power extended throughout the whole of that region not under the British rule. Local insurrection against the Turks followed and autonomy was finally granted to the Zaydi imam in 1911 (Bidwell, 1983).

Clashes with the British over Aden were characteristic of Zaydi Imams' rule, and protection was sought from Cairo, resulting in a short-lived pact between Yemen, Egypt and Syria. In 1962, a military coup led by Colonel Abdullah al-Sallal against the Imams' rule proclaimed a republic. Backed by the United Arab Republic, this new regime was known as the Yemen Arab Republic (YAR).

The deposed imam fled to the mountains of the north, and his Royalist forces, backed by Saudi Arabia, waged a civil war against the YAR, which lasted for eight years. Egypt gave aid to the Republican army and a meeting between Egyptian President Gamel Abdel Nasser and King Faisal of Saudi Arabia in 1965 led to an agreement to end the involvement of both these countries in the civil war. Arrangements were made to hold a plebiscite to allow the people of YAR to choose their own form of government, but this never happened and fighting was resumed in 1966. The war continued until 1970, when the YAR was finally recognised by Saudi Arabia (Bidwell, 1983).

In the late 1960s, British presence in southern Yemen was minimal outside Aden itself. Intense guerrilla fighting throughout the mid-sixties resulted in a British withdrawal from Aden in 1967. With the closure of the Suez Canal, Yemen's economy was on the verge of ruin, and the new People's Republic of South Yemen, which came into being on 30 November 1967, relied heavily on economic support from Communist countries. It became, in effect, the first and only Arab Marxist state. In 1970 the republic's name was changed to the People's Democratic Republic of Yemen (PDRY).

Mutual distrust between the two Yemens characterised the seventies, and tensions flared into a series of short border wars in 1972, 1978 and 1979. By the end of 1981, a constitution had been drafted in order to implement a merger between the two states. Attempts to consolidate this, however, were delayed by political instability in the PDRY and it was not until 22 May 1990 that the merger was made official. The new country was named the Republic of Yemen. The North's population of about 11 million far outnumbered the South's (perhaps 2.5 million), but the unity accords of 1990 divided most governmental posts equally (Dresch, 2000).

Yemen is divided into five regions:

- the Mountain Area: the first is the North-South mountain area parallel to the Red Sea and the second is the West-East mountain range parallel to the Gulf of Aden.
- The Hill Area to the east and north of the mountainous area parallel to it.

- The Coastal Area which includes all areas adjacent to the Red Sea.
- Al-Rub El-Khali Area, part of the Yemeni desert, contiguous to the hill area.
- The Yemeni Islands scattered in the Yemeni territorial waters of the Red Sea and the Arabian sea.

Yemen has a coastline of about 450km and its coastal plain, the Tihamah, averaging 48km in width, is a region of semi-desert. The vast mountain range of the southern Arabian Peninsula runs through Yemen, with its highest peak, Hadur Shu'ayb at 3,760 metres. Topographical variations in this region give rise to a wide range of climatic conditions, and its fertile highland plateaux are ideal for growing a wide variety of both tropical and temperate zone crops. These highland regions are interspersed with wadis -- river valleys which are dry in the summer months.

The northern region is rich and fertile, with regular rainfall provided by the effect of the mountains on the Indian Ocean monsoons. Crops include coffee, cotton, sorghum, corn, oats, barley, dates, almonds, grapes and *qat* (a leaf which is widely chewed by Yemeni people). Farming activities also include the breeding of livestock, such as cattle, sheep and goats. By contrast, only about 2 percent of the southern region is arable and most farming activity here is confined to the Hadramawt valley. Alluvial deposits along the hot coastal strip running from north to south, make some irrigated farming possible. In the north-eastern region of the country, the mountains gradually merge with the Rub al-Khali desert and little agricultural activity beyond herding is possible (Bidwell, 1983).

Yemen is a strongly Arab country in both language and culture. There are many tribal and religious distinctions with regard to location. The people of the Tihamah coastal plain are of mixed Arab and African descent, while other groups are mainly of Arab origin. The Zaidi tribe are Shi'ite Muslims, who inhabit the northern mountain region and whose religious and political beliefs exerted a great influence on Northern Yemen from the 9th century onwards. The Shafii community of Sunnite Muslims, who are widely different in their culture and economic structure and have often been at variance with the Zaidi over social and political issues, dominates the northern and southern lowland regions.

i. Yemen's Economy

Yemen has a long history of civilisation and economic progress. Most of the Yemeni labour force (62 percent) are involved in agriculture and fishing, while the rest are distributed among other sectors (Saif et al., 1992). There are approximately 5.1 million acres of arable land in Yemen (9.5 percent of the total area) of which only 1.1 million acres are under cultivation. Agriculture depends mainly on rainwater, thus production is subject to climatic conditions.

Mineral resources in the Yemen have not been accurately assessed or fully exploited, but are thought to be large. Copper deposits were found near Ta'izz in 1969 and oil was discovered in 1972 in the Tihamah region. It is known that further rich mineral deposits exist, chiefly of zinc, iron, lead, gold, silver, copper, sulphur and nickel. Today, salt is mined at Salif, where deposits are thought to total 25 million tonnes. There are indications that Yemen has considerable unused mineral wealth, such as oil (Hashem et al., 1992). Today, Yemen is expected to be an oil exporting country, which would indicate a positive economic performance for the society as a whole.

Manufacturing industries in Northern Yemen are light. These industries produce cement, paints, and metal and cotton products. Other local industries consist of tanning, spinning, weaving and handicrafts.

Yemen is rated as a low human development country (World Bank, 2000), ranked at 151 out of 174 in the Human Development Index (UNDP, 2000). Yemen had made good progress in many areas, including basic education and health, access to safe water, roads and electrification. It is now above the average of lowest-income countries in many of these, yet there is still far to go in all of them. Yemen was even further back in most of these measures before it suffered the shocks of the Gulf War resulting in cut-off of much foreign assistance and remittance income, the great losses suffered in the civil war, the sharp fall in oil prices during 1979-99, and a rapid population growth.

ii. Summary Demography of Yemen

The latest two censuses of the population in the Republic of Yemen were conducted in 1986 and 1988. The 1986 Census was conducted in the northern Governates (then called the Yemen Arab Republic, Y.A.R), while the 1988 Census was conducted in the southern Governates (then called the Peoples' Democratic Republic of Yemen, P.D.R.Y). According to these censuses, the resident population size in the northern Governates was about 7.8 million and the resident population size in the southern Governates was about 1.8 million. The Republic of Yemen population was estimated to be 11.3 million in 1990 of whom about 21.4 percent lived in urban areas (Central Statistical Organisation, 1992).

In 1988, the crude birth rate (CBR) in Yemen was 52.6 per thousand, while the crude death rate (CDR) was 21.8 per thousand. Accordingly, the annual population growth rate was 3.1 percent. The total fertility rate was 8.2 births per woman making Yemen one of the highest fertility rate countries and hence yielding a high rate of population growth. For the same year, the infant mortality rate was 130 per thousand live birth (Central Statistical Organisation, 1992). Life expectancy is moderate, estimated for the same year at 46.3 years for both sexes.

iii. Yemen's Population Policy

In 1984, the National Committee of Population and Family Planning (NCPFP) was established to strengthen the government capacity to implement population policy in North Yemen. After the achievement of Yemeni unity in May 1990, the Government drafted a national population strategy which, after revision, was adopted as national policy at the National Population Conference in October 1991. The National Population Council was established to oversee the implementation of the policy.

The objectives of the National Population Strategy for the year 2000 are:

1. Reduce the infant mortality rate from 130 to 60 deaths per 1,000 live births and maternal mortality by 50% of its 1990 level (YDHS III, 1997).
2. Reduce the mortality rate for children age 1-4 years by 50 percent.
3. To reduce TFR to reach 6 births per woman by the year 2000 (YDHS III, 1997)
4. Increase immunisation coverage for children under one year of age to 85 percent or more, and to expand tetanus immunisation among women of reproductive age.
5. Reduce by 50 percent, compared with the 1990 levels, the number of deaths among children due to diarrhoea.
6. Achieve a population growth rate of 2 percent by the year 2000 (YDHS III, 1997).
7. Achieve a tangible change in the quality of life of the population through the following goals: increasing the enrollment in formal education to 85 per cent of the children in the age group 6-12, especially among girls in rural areas; intensify work in health care, especially in primary health care and expanding programmes of family planning care services; improving living conditions of the population, satisfy their basic needs and raise income levels (YDHS III, 1997).
8. Achieve a population distribution between urban and rural areas that corresponds to the prevailing environmental, economic and production requirements (YDHS III, 1997).
9. Care, protect and improve the environment (YDHS III, 1997).
10. Follow up and assess overall comprehensive development programme and develop their capacities (YDHS III, 1997).
11. To develop and improve population-related legislation (YDHS III, 1997).
12. Increase the use of contraception to 35 percent among women of reproductive age, and expand the family planning services to men;
13. Make family planning a free choice to couples, a basic human right, as well as a factor for social change. Family planning must also include the right to treatment of infertility

(Central Statistical Organization, 1992)

After its unification the new republic caught-up with the second phase of the Demographic and Health Surveys (DHS II) in 1991 (Nov - Jan 1991/92) as the first representative sample of the two countries. The PAP-CHILD survey is the same sample survey as the Yemen Demographic and Maternal and Child Health Survey (YDMCHS, 1991/92), which was conducted by the Central Statistical Organisation of Yemen, in cooperation with the Ministry of Health, the Demographic and Health Surveys (DHS) program of Macro International Inc., and the Pan Arab Project for Child Development (PAP-CHILD). Recently the Republic has carried out the second round of its Demographic and Health Surveys (DHS III) in the period between September and November 1997, the report and summary of which was published in November, 1998.

1.6.1 Differentials in Early Childhood Mortality – from WFS to DHS/PAP-CHILD

Earlier data collection for the region has been the Yemen Fertility Survey (YARFS, 1979) - conducted in the Yemen Arab Republic (northern Yemen) at the time – representative of only the northern part of the newly formed Yemen Arab Republic. For the five years before the survey, the estimate for infant mortality was 160 per thousand (with some evidence to suggest it could be as high as 190 per thousand) and for all mortality before age 5 is 240 per thousand. This corresponded to a mortality regime in which more than one in four children dying before reaching their fifth birthday. Infant mortality rates appeared to be higher for males than females, although this may have been due to the understatement of female deaths. It was females who were reported to have had the greater likelihood of death between the ages of one and five years. Although these levels of mortality remained high, it had fallen significantly in the two decades before the YARFS (1979).

Adlakha and Suchindran (1985) using YARFS (1979) identified a number of correlates of child mortality despite some missing data on the age at death. A persistent pattern of mortality differentials by sex was found in the data. One key correlate was the length of birth intervals; short birth spacing had a substantial and negative influence for all ages of survival. They suggested the factor was operating through both a biological mechanism (because of lower birth weights associated with short intervals) and a behavioural mechanism (competition of children for mother's time).

During early months after birth (0-11 months), birth spacing, birth order and survival status of the previous child have a significant effect on chances of survival (maternal age at birth influences neonates survival chances). For later childhood, disadvantage by socio-economic factors has more impact on chances of survival. For the child mortality, only birth interval, residence and father's occupation showed statistical significance.

For all birth cohorts between 1961 and 1978, male neonatal and post-neonatal mortality exceeded female neonatal mortality, but male childhood mortality was less than corresponding female mortality. This pattern suggests preferential care and treatment of male offsprings, a feature common to some Islamic societies like Yemen.

Mortality differentials by region of residence were also identifiable; the North and West regions showed very high mortality during infancy and early childhood as compared to the East region.

YDMCHS (1991/92) estimates show that child mortality remains high in Yemen, an under-5 mortality rate of 122 deaths per thousand births and an infant mortality rate of 83 per thousand live births. Yemen might not achieve the UN target of Under-5 mortality rates of 70 per thousand by the year 2000, nevertheless the transition towards lower mortality levels continues.

Further to the findings of Adlakha and Suchindran (1985) of lower early childhood mortality for male births, Timæus, Harris, and Fairbairn (1998), using YDMCHS (1991/92) report clear evidence of systematically greater use of health services by male than female children.

Where previous birth intervals are less than 2 years, levels of under-five mortality are almost twice those when the interval between the child and next older sibling is more than 2 years (182 per thousand as compared to 89 per thousand). The gap is even larger for estimates of infant mortality rate (IMR) of 131 per thousand when birth intervals are less than 2 years compared to 60 per thousand when birth intervals are more than 2 years (YDMCHS, 1991/92).

The IMR in rural areas and in the northern and western Governates is 100 per thousand as compared to 89 per thousand in urban areas and 79 in the southern and eastern Governates. Under-5 mortality is around 143 deaths per 1,000 births in rural areas and in the northern and western Governates compared to 116 in urban areas and 102 in the southern and eastern Governates. The IMR is almost halved when mothers have more than primary schooling as compared to the illiterate groups (57 per thousand as compared to 101 per thousand).

According to YDMCHS (1991/92), poor maternal and childcare, inadequate socio-economic and environmental conditions, poor feeding and nutrition habits, and lack of awareness about the need for vaccination and the vaccination schedule are major drawback to improving child mortality levels. Many children in Yemen are vulnerable to vaccine-preventable diseases. Approximately four out of 10 children under age five were fully immunised; about the same proportion had received no vaccinations at all. Urban children, however, were more likely to be fully immunised. More than seven out of 10 urban children ages 12 to 23 months were fully vaccinated. As with other countries of the developing world, much of child illness can be explained by what have been called "proximate determinants", principally infant feeding practices and preventive and curative care. Myntti's (1993) field research in a small village in Yemen, observed that despite the uniformly unhealthy environment, a minority of the families carried most of the burden of child illness and death. Myntti (1993) observed that what distinguished women with healthy and unhealthy children was the level of resources under their control and the way they managed them; their social support or lack of it; and their passive or active attitudes toward life.

Table 1.6 below summarises the changing rates in Total Fertility Rates (TFR) and childhood mortality for the last two decades. Yemen's mortality transition is underway - between the late 1970s and 1980s, early childhood mortality rates have almost halved. However, the consequential fertility transition is much slower – by the latest estimate figures of YDHS (1997), the TFR stands at 6.5 births per woman. Although the level of contraceptive use is still very low in Yemen- especially compared with neighbouring countries- it has doubled since 1991-92 from 7 to 13 per cent (YDHS, 1997). Too many births, early marriage, pregnancy at too young or too old an age, and short intervals between births are contributing factors adversely affecting the health of mothers and children in Yemen.

Table 1.6: Summary of TFR, IMR and Under-5 estimated from Yemen's WFS and DHS.

Yemen		Child Mortality	
	Total Fertility Rate (per woman)	Infant Mortality Rate (deaths / 1000 births)	Rate of Death under age 5 (deaths / 1000 births)
YARFS 1979	8.5	162	237
YDMCH 1991/92	7.7	83	122
YDHS 1997*	6.5*	75	105

* Estimate based on the 3-years preceding the survey

To conclude sections 1.4, 1.5 and 1.6, Table 1.1 offers a summary of recent socio-economic and demographic indicators across countries. Relatively speaking, advantaged indicators are those for Egypt, followed by Sudan and lastly Yemen.

Table 1.1: Recent Socio-Economic and Demographic Indicators

	Egypt	Sudan	Yemen
Demographic, Social and Economic Indicatorsγ			
Total Population (millions) 2000	68.5	29.5	18.1
Projected Population (millions) 2025	95.6	46.3	39.0
Average Population Growth Rate (%) (1995-2000)	1.9	2.1	3.7
% Urban (1995)	45	34	25
Urban Growth Rate (1995-2000)	2.6	4.7	5.9
Total Fertility Rate (1995-2000)	3.4	4.6	7.6
% births with skilled attendants	46	86	43
GNP per capita PPP$ (1998)	3,146	1,240	658
External Population assistance (US$,000)	36,092	3,931	10,508
GDP at market price (Current US $)*	82.7 billion	10.7 billion	6.0 billion
GDP Growth Rate (annual %) *	5.6	5.0	4.8
GNP per capita, Atlas Method (Current US $) *	1,280	290.0	350.0
Access to Safe Water	84	60	39
Monitoring ICPD Goals Selected Indicators ⊕			
Indicators of Mortality			
Infant Mortality Total per 1,000 live births	51	71	80
Under-5 mortality M / F	65 / 64	115 / 108	112 / 114
Life Expectancy M / F	64.7 / 67.9	53.6 / 56.4	57.4 / 58.4
Maternal Mortality ratio/100,000 live births	170	--	350
Indicators of Education			
Primary Enrolment (gross) M / F	108 / 94	55 / 47	100 / 40
Proportion reaching grade 5 M / F	95 / 93	90 / 95	--
Secondary Enrolment (gross) M / F	83 / 73	23 / 20	53 / 14
% Illiterate (> 15 Years) M / F	34 / 57	31 / 55	34 / 76
Reproductive Health Indicators			
Contraceptive Knowledge			
% Knowing Method	100	71	60
% Knowing Source	93	60	27
Births per 1,000 women aged 15-19	65	52	102
Contraceptive Prevalence			
Any method	47	8	13
Modern methods	46	6	10

Sources : ⊕ - The State of World Population, UNFPA, 2000;

* - World Development Indicators database (1998), July 2000.

1.7 The Middle East and North Africa Context

This introductory chapter may not be complete without an informative placement of the socio-economic and demographic picture of the countries concerned within their regional context. The interaction between cultures in this broadly defined region is partially responsible for the diffusion of many social, political, cultural and linguistic traits. Important advances in science and technology in the past few decades have opened up new vistas for health and demographic change in the region. Their potential positive impact on the health status of the region remain very promising, especially from the point of view of preventing death, disease and disorder. These developments however are heterogeneous in existence benefiting mostly urban rather than rural populations, richer rather than poorer settings. The following sub-sections are brief overviews of the socio-economic, demographic and public health patterns of the region.

1.7.1 The Social and Economic Context:

Since this thesis is concerned with mortality of children, it would be interesting to learn about the position of children defined within the family setting. The Middle Eastern family has been described as "patrilineal, partilocal, patriarchal, extended, endogamous and sometimes polygnous (Patai, 1971). However, polygny rarely rises above 10-15 per cent in the Middle East compared with rates as high as 50 percent in Tropical Africa (Caldwell, 1977). Not so long ago, Islam was considered by some as a major obstacle to the diffusion of family planning, fertility control and modern demographic behaviour. Allman (1978) acknowledges that religious support for pro-natalist behaviour is much less important among Muslims than was at earlier times. In fact, it can be argued that Islam is more favourable to family planning than other religions and that the obstacles to economic and social development which many Islamic countries face are the major determinants of their "traditional" demographic behaviour (Kirk, 1966). Watson and Lapham (1975) further argue that some states are pro-natalist and favour polices that increase their native populations; most give more importance to demographic factors as elements of planning of social and economic development than to influencing family size; and all stress family planning rather than birth control.

To return to the stance of the value of children within a family setting, two accurate observations come from Caldwell (1977) in the case of Egypt and Galal el Din, (1977a, 1977b) in Sudan.

Caldwell (1977) observes:

> The urban elite spend more upon their children and plan to educate them further, so that the net intergenerational wealth flow has clearly reversed. All rural residents reported that, not only do children – even school children- easily earn their keep, but also that family prosperity increases with family size. A major reason for sustained high fertility, even amongst the traditional urban middle class, has been the lack of alternative roles for women. A process of development of strong conjugal bond is causing a tight nuclear family to crystallise out from the emotional and economic ramification of the extended family. Helped by residential nucleation, especially when such residence is at great distances from the families of origin, as is likely to be the case with rural-urban migrants. Thus with these changing relationships, children become relatively dearer, especially in the circumstances of urban areas where the opportunities for consumption expenditure are multiplying rapidly.

For rural Sudan, Galal el Din (1977a) observes:

> In Sudan, most communities try to achieve the highest possible childbearing capacity. Birth spacing is employed only as an aid to ensure that the greatest possible number of children survives. High fertility has an economic rationality. The cost of bringing up a child is relatively cheap for individual families. Firstly, in areas where there are no educational facilities (as indeed is the case in most parts of Western and Southern Sudan, as well as among nomadic and semi-nomadic populations), the period of rearing a child is very short. As soon as a child is six or seven years of age, he starts to contribute to production rather effectively. Secondly, in most cases in rural Sudan, the up-bringing of a child is not the responsibility of the parents alone but rather diffused among members of the extended family. All scientific studies in rural Sudan, including this one, show the importance of children as an economic factor and conclude that given the prevailing social, economic and political setting in rural Sudan, high fertility constitutes rational economic behaviour. A pilot study conducted in the Gezira Scheme (Galal el Din, 1975) show that in 1974 there were about 50 thousand children under ten years of age participating in cotton picking, which constitutes more than eight per cent of the total labour force involved in picking. Independent adult children also fulfil their obligations towards their parents, thus making it even more certain that there is eventually economic gain to parents from children.

Galal el Din (1977b) further observes for urban Sudan:

> Among the different (urban) social classes it seems that income or occupation per se has very little to do with fertility differences. Among merchants, businessmen and their relatives, prefer their sons to join them in business directly, rather than proceeding to higher levels of education. A trend rapidly changing and merchants are increasingly anxious that their sons should get a university degree. From a woman's point of view, high fertility enhances her security and well-being in a number of ways, competition between other wives, desire together with her own children to get the greatest part of the husbands' wealth after his death (according to Islamic Sharia). The rationality of high fertility among the urban poor is less obvious since those tend to live in miserable and perhaps worsening conditions and feel increasingly uncertain about their future and that of their children. Having a large family is one way by which people hope to achieve a better future, even in those circumstances where it makes survival somewhat more difficult in the short term. ***It is indeed a risk for the poor to have many children, but it is a calculated one and in most cases a conscious calculation of long-term gains.***

Significantly, the countries that make up today's Middle East display the broadest possible variety of socio-economic development, their per capita incomes widely ranging from the world's highest down to the lowest, according to UN estimates. The past decades' steady shift from a largely tradition-bound rural society to a more urbanised, technologically-oriented one, has brought about milestone changes in the region and changes on the health care horizon has been correspondingly great.

One social trend that is quite complex in this region is its specific situation of poverty – this is due mostly the political situation prevailing and the direct consequence of continued armed conflicts. Poverty, assessed in terms of low income, appears to be at its worst in rural areas. It tends to be the same in urban and rural areas when measured by morbidity, lack of education, short life expectancy and substandard housing. The large influx of refugees and the massive return of the workforce as a result of the Gulf War significantly worsened the picture in this context. Health status has also deteriorated as a consequence. Despite some substantial efforts made in food production in recent years, self-reliance in this field remains a remote target.

1.7.2 The Demographic Context:

Early efforts of applying the demographic transition model to the Middle East and North Africa suffered from a lack of data. Allman (1978) characterised Saudi Arabia, United Arab Emirates, Qatar, Oman, Libya, Iraq, Sudan and North Yemen in a second stage of the transition with declining mortality, high and possibly increasing fertility (as a result of a process of modernisation due to changes in reproductive behaviour and increases in fecundability related to improved health conditions, nutrition, and changes in breast-feeding practices). Morocco, Algeria, Jordan, Bahrain, Kuwait, Iran, South Yemen and Syria were at a stage of declining mortality and high, but probably at maximum levels, fertility (part of the same process mentioned earlier). But Turkey, Tunisia, Egypt, Lebanon possessed declining mortality and declining fertility – hence none of the countries were at the first or last phase of the demographic transition of high mortality, high fertility or low mortality, low fertility levels, respectively. Using his approximate classification of countries, Allman (1978) observe all were undergoing mortality declines, which are likely to continue in varying degrees in the years ahead.

Table 1.7.2 could offer an appraisal of Allman's classification; countries continue to re-group. United Arab Emirates leaves the group above by a sharp decline in fertility, whilst the others remain in the second stage. Similarly, only Morocco and Yemen (South) are still at a stage of declining mortality and probably maximum levels of fertility. As a member of the group of declining fertility and declining mortality stage, Egypt is perhaps slower in acquiring further declines to mortality.

Also illustrated in Table 1.7.2., are the changes in life expectancy which are likely to be closely tied to changes in infant and child mortality, particularly at high levels of overall mortality. Thus, the constant decline in child mortality measure may be consistent with the rates of improvement in life expectancy.

The intercountry ranges in the patterns of nuptiality, fertility, mortality, family-size desires and contraceptive prevalence can be broadly related to ranges in education, income distribution, access to health facilities, provision of family planning services and many other factors that characterise the milieu in which the people of the Arab region live and function (Farid, 1984). With regard to fertility decline, Farid (1984) adds that the results of the Arab fertility surveys indicate that the transition from high to lower fertility in several countries is influenced by the rise in age at marriage and the reductions in child mortality – social and economic changes that reduce the number of children that couples desire. Individual choices about family size, however, remain with a pronatalist attitude – and not only among older women but also among younger cohorts. Contraceptive use in the Arab region is relatively low among younger women who have fewer than three children, and it rises substantially after that (Farid, 1984). This pattern suggests that there is a scant reliance on contraceptives for spacing purposes and that most of the Arab women who practice contraception do so to terminate childbearing.

Table 1.7.2 below describes the stratification of the Middle Eastern region in two mortality strata: High Child, High Adult mortality and Low Child, Low Adult mortality, respectively (Murray et al., 2000: p.29). Apparent correlations are those of low fertility (TFR) and low child mortality (IMR) which in turn lead on to gains in life expectancy and lower population annual growth rates. A key observation to make is that the three countries of concern to this study belong to the "high child and high adult" mortality stratum.

Table 1.7.2: Recent Demographic Indicators of the Middle Eastern Region. *World Population Prospects: 1998 Revision. New York, United Nations, 1999*

Mortality Stratum	Population (000) 1999	Annual Growth Rate 1990-99	Dependency Ratio			Total Fertility Rate (TFR) (per woman)			Infant Mortality Rate (per 1000 livebirths)			Life Expectancy at birth (years)			Mortality Under Age 5 (per 1000 livebirths)	Maternal Mortality Ratio per 100000
			1978	1990	1999	1978	1990	1999	1978	1990	1999	1978	1990	1999	1999	1990
High Child, High Adult																
Afghanistan	21,932	4.5	86	80	78	7.2	6.9	6.9	183	170	151	40.0	41.5	45.5	257	1700
Djibouti	629	2.2	86	85	79	6.7	6.2	5.3	143	122	106	43.0	47.0	50.4	174	570
Egypt	67,226	2.0	79	77	73	5.3	4.8	3.4	131	75	51	54.1	61.0	66.3	65	170
Iraq	22,450	2.4	96	92	85	6.6	6.2	5.3	84	64	95	61.1	64.7	62.4	116	310
Morocco	27,867	1.7	103	83	65	5.9	4.3	3.1	110	75	51	55.8	61.9	66.5	68	610
Pakistan	152,331	2.8	91	85	84	7.0	6.0	5.0	130	100	74	53.4	58.9	64.0	106	340
Somalia	9,672	2.5	96	101	100	7.3	7.3	7.3	149	132	122	42.0	45.0	47.0	204	1600
Sudan	28,883	2.0	89	88	82	6.7	5.4	4.6	97	86	71	46.7	51.0	55.0	112	600
Yemen	17,448	4.7	115	108	100	7.6	7.6	7.6	158	105	80	44.1	52.9	58.0	113	1400
Low Child, Low Adult																
Algeria	30,774	2.4	107	92	75	7.2	5.0	3.8	112	67	44	57.5	65.1	68.9	51	940
Bahrain	606	2.4	83	51	52	5.3	4.1	2.9	43	21	16	65.9	70.4	72.9	22	60
Cyprus	778	1.5	56	56	57	2.3	2.4	2.0	20	11	8	73.7	76.1	77.8	9	5
Iran	66,796	1.9	95	94	95	6.5	5.7	2.8	100	53	35	58.6	64.7	69.2	52	120
Jordan	6,482	3.8	100	103	85	7.4	6.0	4.9	65	54	26	61.2	65.9	70.1	31	150
Kuwait	1,897	-1.3	85	62	68	5.9	3.9	2.9	34	16	12	69.6	74.0	75.9	15	29
Lebanon	3,236	2.7	86	74	66	4.3	3.4	2.7	48	41	29	65.0	67.0	69.9	35	300
Libya	5,471	2.4	93	95	85	7.4	5.7	3.8	63	37	28	57.7	66.7	70.0	32	220
Oman	2,460	3.6	87	99	94	7.2	7.0	5.9	95	37	25	54.8	67.7	70.9	30	190
Qatar	589	2.2	55	41	40	6.1	5.5	3.7	46	23	17	65.6	69.4	71.7	23	--
Saudi Arabia	20,899	3.0	90	84	79	7.3	6.8	5.8	75	37	23	58.8	67.5	71.4	37	130
Syria	15,725	2.7	109	105	92	7.4	6.6	4.0	67	49	33	60.1	65.0	68.9	40	180
Tunisia	9,460	1.7	90	77	65	5.7	4.1	2.6	88	49	30	60.0	65.6	69.5	37	170
UAE	2,398	2.5	43	42	47	5.7	4.6	3.4	38	24	16	66.8	72.4	74.8	19	26

1.7.3 *Communicable Diseases And Health Challenges:*

As members of the WHO Eastern Mediterranean Region (EMR), the three countries have endorsed the Alma-Ata Declaration (1978) on primary health care (PHC). The strategy of Health for all by the Year 2000 (HFA/2000) is based on the concept of countrywide health systems along the lines of PHC. *"Health for All"* as a policy in the Region continued to receive endorsement at the highest levels – Egypt, for example, has declared the 1990s as the "Decade for Child Protection", with specified targets and activities, while Sudan has declared health as the first national priority after security.

This section is a selective review of the regional health progress in challenging communicable diseases, largely based on the WHO/ EMRO second evaluation on the progress of implementation of the Global Strategy for *Health for All* by the year 2000 (WHO/EMRO, 1996). Since the first evaluation of the Strategy in 1985, a great deal of progress has been achieved. One critical aim was for a more equitable distribution of resources and facilities by giving priority to extending PHC to underserved population groups. For example, Egypt introduced or extended coverage of health insurance in one form or another and Yemen started implementing the "basic minimum needs" (BMN) approach. Imperative to all localities is the quality of services in the health care system and ways to improvement if people are to use them. Egypt and Sudan resorted to the same approach of restructuring and renovating existing facilities to suit PHC approach (WHO/EMRO, 1996). Still the region experiences a number of ecological and epidemiological challenges; what follows is a selective review of those.

- **Epidemics / Endemics**

One of most serious outbreaks and / or epidemics the region witnessed was that of meningococcal meningitis. Of those, and of relatively high magnitude (at least 2-3 times the median incidence for 1985-1988), outbreaks were reported from Egypt and Yemen (all in 1988) and Sudan (in 1988, with more than 32,000 cases) (WHO/EMRO, 1996).

Hepatitis A in endemic in the EMR and the prevalence of Hepatitis B (Seropositive) is 2-10%; thus epidemiologically considered of moderate to high endemicity. Because of the serious sequelae of hepatitis B, immunisation of infants included it in the three countries national immunisation programmes. HIV infections and AIDS were not reported in the first evaluation in 1985. Since then AIDS has gained considerable prominence, although the number of AIDS cases reported in the region is still relatively low compared with other WHO regions. Yet *all* countries have national plans for the prevention and control of AIDS, but their rate of implementation needs considerable acceleration if the programme is to be effective in achieving its goals.

Acute respiratory infections (ARI) appear as the first or second leading cause of mortality among infants and young children is many countries, sharing these positions with diarrhoeal diseases. All countries with mortality rates from diarrhoea of over 20 per 1000 children under three years of age are implementing countrywide control programmes through PHC. Data from the Demographic and Health surveys suggest that only a small fraction of children thought to have ARIs actually received antibiotic treatment. Those studies that have been conducted suggest that appropriate case management can reduce infant mortality by 20 per cent and under- five mortality by 25 per cent. Ewbank and Gribble (1993) speculate, given what is known about current levels of antibiotics treatment for ARI, health programmes in sub-Saharan Africa (Sudan included) probably are not having much effect on overall mortality rates.

- **Nutritional Status**

The dietary problem of young children in poverty-stricken areas is not so much one of mere hunger but of hunger for the right food. Widespread ignorance about foodstuffs that can be used in weaning diets is blamed for countless cases of malnutrition among them. The poorest tend to be those who are worst fed and of course least healthy. Studies carried out in the Egyptian countryside shows a highly significant relation between the prevalence of diarrhoea, especially in its recurrent forms, and malnutrition (Simon, 1980).

Undernutrition maybe a poor indicator of lack of food; de Waal (1991) takes this view and argues that anthropometric data reveal so little about food insecurity that there is little point in collecting them. Undernutrition may result from there not being enough to eat; it may equally result from poor sanitation, ill-health or inappropriate feeding practices (Beghin, 1988).

The sub-Saheline drought in 1983-85 precipitated a widespread famine in Sudan.

Working with data from the SERISS[2] project, El Amin and Grobler (1991) asserted that undernutrition is widespread across North Sudan with the highest levels being found in areas of high agricultural output, reflecting poor access to food. El Amin and Grobler (1991) concluded that undernutrition is the result of ignorance, the lack of purchasing power, the non-availability of subsistence food and the high prevalence of communicable diseases.

de Waal (1991) argues that the importance of nutrition appears to lie in the speed of recovery from disease episodes since clinical and epidemiological work has shown that the incidence and severity of the major diseases which threaten life in famines are little affected by mild or moderate undernutrition: measles (Aaby 1988), malaria (McGregor et al., 1965; Murray, 1978; Mann, 1980), typhoid (Reddy, 1976), diarrhoeal diseases (Black, Brown, and Becker, 1984) and cholera (Passmore, 1951).

There is an unstable and inequitable food system in Sudan, which has been subject to a high degree of intervention, in production, marketing and consumption (Hussain, 1991). The short-term shocks of the war in the South further exacerbate the situation. There is no doubt that an end to the war is the single most important requirement for food security. Drought is affecting agricultural output, employment and prices. Shepherd (1991) argues that in longer term, drought would result in permanent migration, the sedentarisation of nomads, further landlessness and family breakdown.

- **Malaria**

Malaria remains a substantial problem especially in Sudan and Yemen, where a national control programme is in full implementation. It is considered to affect children after the neonatal period. In highly endemic areas children and pregnant women are the most vulnerable to attacks, as other adults tend to acquire a degree of immunity through continued exposure (WHO, 1999). In Sudan, and towards the northern part, the risk is of epidemic proportion, whilst the rest of the country is considered as an area of stable transmission (Snow, 1998).

In Sudan and Yemen, there is an increased prevalence of *Plasmodium falciparum* malaria with confirmed cases of P.falciparum resistance to chloroquine. Also, the major malaria vectors have become resistant to insecticides, so that their control by residual chemical insecticides is becoming increasingly costly and difficult. Added to

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[2] Sudan Emergency Recovery Information Surveillance System, conducted in Northern Sudan from 1986-87, covering 80,000 children under age five and aimed at assessing their nutritional and health status.

that is the prevailing circumstances which do not permit effective implementation of control measures. Control is basically through DDT spraying but resistance has developed and concerns about safety emerged. Innovative approaches are being implemented towards the integration of malaria control through PHC in certain districts on a trial basis in Sudan, or as with other parasitic disease programmes in Egypt. The active role that the community can play in control efforts is increasingly seen as in the Blue Nile project in Sudan and in areas of Yemen. Operational and administrative shortcomings, and the lack of matching financial support and the quadrupled costs of oil-derived insecticides, are among the factors blamed for such setbacks. Both Sudan and Yemen have signed-up to the mobilisation of the research community with the launch of the Multilateral Initiative on Malaria (MIM) (Dakar, Senegal, Jan 1997). Insecticide treated bed-nets and effective treatment of children could bring reduction in the burden of disease. Chemoprophy laxis or presumptive treatment during pregnancy is encouraged but in practice fewer than 20 per cent of women are effectively covered (WHO, 1999). One major set-back is the lack of country representative figures of the incidence and reported deaths from malaria.

Table 1.7.3.1 Malaria, magnitude of the problem by age, sex and the WHO region, estimates for 1998

	Both Sexes	Males		Females	
		0-4	5-60+	0-4	5-60+
Africa					
Deaths (000)	961 (87%) (100%)	391 (41%)	107 (11%)	354 (37%)	109 (11%)
Incidence (000)	237647	47798	71060	47132	71657
East-					
Mediterranean	53 (5%) (100%)	19 (36%)	7 (13%)	17 (32%)	8 (19%)
Deaths (000)	13963	2437	4433	2398	4424
Incidence (000)					
Other regions					
Deaths (000)	93 (8%) (100%)	7 (8%)	41 (44%)	5 (5%)	40 (43%)
Incidence (000)	19542	1270	8535	1205	8532
All Member States					
Deaths (000)	1110 (100%) (100%)	417 (38%)	154 (14%)	376 (4%)	161 (14%)
Incidence (000)	272925	51627	84945	50847	85507

Source: World Health Report 1999, Annex 8 (p.115) based on estimation from Snow et al (1998)

In the tabulation presented by Table 1.7.3.1, the three countries are considered as members of the Eastern Mediterranean region. Africa has the highest percentage (around 87 percent of deaths) compared to other regions. North Africa is densely populated among the Mediterranean and Moroccan coast; however, the majority of these areas do not support stable P.falciparium – in addition, the WHO regional offices covering these areas reported no cases of malaria (Algeria, Egypt, Libya, Morocco, Tunisia) and are excluded (Snow, 1998). The remaining part of the region, including Sudan and Yemen, bear 5% of the burden of deaths from malaria, two-third of whom are children under age five.

Supported by *Roll Back Malaria*, which seeks to halve the world's malaria burden by the year 2010, national training facilities, supplies and equipment have been improved in Sudan. The Blue Nile Health Project (BNHP 1980-1990) was launched in 1980 mainly for control of water-associated diseases in central Sudan. The Gezira, Managil and Rahad irrigation systems, all irrigated from the Blue Nile River, were selected for the project area as typical of irrigation systems throughout Africa and the Middle East where malaria, diarrhoeal diseases and schistosomiasis are endemic, and as the areas most urgently in need of disease control in the Sudan. The methods used for control of the water-associated diseases emphasize permanent improvements in water supply and sanitation, in environmental and agricultural practices, in health education, community participation and primary health services, and a reduction in dependence on pesticides and drugs. The malaria interventions are treatment and prophylaxis. The decrease in the case fatality rate after presumptive treatment with chloroquine was considered to be only 20 per cent. The efficacy is low because much of the presumptive self-treatment of fever with chloroquine is of questionable appropriateness and because of resistance to chloroquine (Campbell, 1991; Greenwood, 1988; Ruebush et al. ,1995).

- **Burden of Disease**

In the last two decades, considerable international effort has been put into the development of summary measures of population health that integrate the information of mortality and non-fatal health outcomes. One comparative index of the burden of each disease or injury, is the number of Disability-Adjusted Life Years (DALYs) lost as a result of either premature deaths or years lived with disability (Murray and Lopez, 1996).

Table 1.7.3.2 below is based on recent figures of the World Health Report (WHO, 2000) which divides countries of the Middle East into two strata: high child high adult mortality and low child low adult mortality strata (Murray et al., 2000: p.29). Clearly, the three settings of concern are in the "high child high adult" mortality stratum. In general, the latter stratum has close to half of its estimate of total DALYs lost for communicable diseases, maternal, perinatal and nutritional deficiencies. Of that, preventable childhood diseases constitute 12 per cent (6161 compared to 52,472).

Table 1.7.3.2 Magnitude of DALYs lost by WHO region, estimates for 1998

	Mortality Stratum									
	[A]Low Child Low Adult					[B]High Child High Adult				
Population (000)	136,798 (000)					348,468 (000)				
i. Communicable Diseases, maternal, perinatal and nutritional deficiencies	5,858				(28%)	52,472				(52%)
Infection and Parasitic		2337					26485			
Tuberculosis			225					2035		
Childhood			399					6161		
Measles				273					3020	
Tetanus				35					1786	
Pertussis				83					1332	
Meningitis			156					1316		
Malaria			47					2727		
Tropical Diseases			52					333		
Respiratory		980					9936			
Maternal Conditions		704					2016			
Perinatal Conditions		1134					10621			
Nutritional Deficiencies		704					3415			
ii. Non-Communicable Diseases	12568				(60%)	38471				(38%)
iii. Injuries	2469				(12%)	10745				(10%)
Total DALYs (000) (i. + ii. + iii.)	20,895				(100%)	101,688				(100%)

A) Bahrain, Cyprus, Libya, Iran, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Tunisia, UAE
B) Afghanistan, Algeria, Djibouti, Egypt, Iraq, Morocco, Pakistan, Somalia, Sudan, Yemen

World Health Report 1999: Making a difference. Geneva, Switzerland, World Health Organisation.

Becker and Black (1996) argue that preventive measures may have a greater impact on mortality than curative measures if they prevent multiple diseases. An example is Vitamin A supplementation, which has been shown to protect children against death from a number of infectious diseases (Sommer et al., 1986; Beaton et al,. 1993). Although the clinical efficacy of curative interventions maybe known, the extent to which they can reduce mortality in a given community setting is unclear for two reasons--competing causes of death and frailty (Becker and Black, 1996). Measles vaccine has been shown to lead to similar reductions (Aaby, Bukh, Lisse, and Smits, 1984; Clemens et al., 1988; Koenig, 1990), and it has been argued that ORT reduced overall infant and child mortality by more than 30 per cent in Egypt (El-Rafie et al., 1990).

In the World Health report (WHO, 2000) a new summary measure of health is used, Disability-adjusted Life Expectancy, or DALE. DALE measures the equivalent number of years of life expected to be lived in full health, or healthy life expectancy (Mathers et al., 2000). Unlike other forms of health expectancy, it takes into account differences in the severity distribution of health states between populations (Mathers et al., 2000).

Table 1.7.3.3. Health Attainment, level and distribution for selective Estimates 1997-99*

	Egypt		Sudan		Yemen	
Life-expectancy at birth (years)		66.3		55.0		58.0
	Rank	DALE Estimate	Rank	DALE Estimate	Rank	DALE Estimate
Disability Adjusted Life Expectancy at birth (years)	115	**58.5**	154	**43.0**	141	**49.7**
Distribution of Equality of Child Survival Index	141	0.643	159	0.595	165	0.558
Responsiveness of Health Systems level (Index scale 0.0-10.0)	102	5.06	164	4.34	180	3.98
Responsiveness of Health Systems Distribution (Index scale 0.0-1.0)	58	0.979	148-49	0.842	189	0.673
Fairness of financial contribution to health systems (estimate for 1997)	125-27	0.915	160-61	0.883	135	0.910
Total expenditure in Health as % of GDP (estimate for 1997)		3.7		3.5		3.4
Total expenditure in Health as % of total public Expenditure (estimate for 1997)		3.3		9.6		3.3
Overall health system attainment, WHO index, (estimates for 1997)	95-114	73.5	141-58	62.3	140-46	62.3
Overall health attainment ranked		110		148		146

* World Health Report 2000: Health Systems, Improving Performance. Geneva, Switzerland, World Health Organisation; Ranks out of 191 countries.

DALYs measure the gap between a population's actual health and some defined goal, while DALE belongs to the family of health expectancies, summarising the expected number of years to be lived in what might be termed equivalent of "full health" (Mathers et al., 2000). First to reduce is the average loss in life expectancy which is greatest for Sudan, where the estimate of life expectancy drops from 55 to 43 years due to the burden of disease, the equivalent of a 22 per cent drop. The corresponding drop is about 8 years in the case of Egypt and Yemen, respectively. Interesting to note is the index of equality of child survival index; the deviation of the index away from unity indicates the lower chances of survival by increasing parity, once more desperately low for Sudan and Yemen and somewhat better in the case of Egypt. Other indices of responsiveness of health systems and their distribution, place Egypt at a better scoring level compared to Sudan and Yemen. The claim for Sudan is that close to 10 per cent of the total public expenditure goes to the health sector, yet a huge gap remains in the overall health system attainment.

1.7.4 *Reflections on Health Policy:*

In this sub-section the aim is leave the reader with a final note on the strategies of country-specific priorities in health policies.

Egypt's health policy continues full force behind a health system based on PHC, which is provided through various health establishments such as MCH centres, school health units and health offices, as well as urban health centres. Through these centres the MOH conducts various campaigns such as the national immunisation campaign against childhood diseases, the nation campaign for immunisation of pregnant women again tetanus, expansion of health visitors schemes and campaigns against schistosomiasis and for the eradication of poliomyelitis. A new policy also dictates that all schools with one thousand pupils or more will be provided with school health clinics; 80 of these clinics have already been established and 50 more are being renovated. Despite, the commitment to improve the coverage and services of health care system health care delivery in Egypt still faces significant problems. Both health facilities and staff tend to be unevenly distributed, clustering in urban areas, especially in Cairo and Alexandria. It is quite evident from the improved health status of the population that health strategies have been effective. There was a general decline in mortality, including general, neonatal, infant, child and maternal mortality. The formation of the National Council for Childhood and Motherhood in 1988 was paramount for the delivery of programmes of child survival and development (WHO/EMRO, 1996).

In the case of Sudan the national health strategy first formulated in 1980 was updated in 1988 laying special emphasis on: 1) encouragement of national and foreign voluntary organisation to provide services through the existing health institutions, 2) family health and reduction in morbidity and mortality rates among mothers and children (who constitute 70 per cent of the population), 3) encouragement of community involvement in the planning, implementation and supervision of health services, 4) reinforcement of PHC and the delivery of its integrated components through the area health system, 5) co-ordinated development of the different levels of the health system, 6) encouragement of scientific research into the more pressing health problems, including environmental pollution, endemic and epidemic diseases and malnutrition, 7) improvement of the managerial skills of personnel at all levels. Emphasis on co-ordination between health related ministries and departments, 8) community involvement through a series of consultations, working up through all levels and culminating a national conference for finalisation of recommendations and adoption in May 1990. Several constraints hinder the full implementation of the strategy. Among these are the severe national economic difficulties, continuing problems, serious problems of communication and logistics within the country, lack of motivation in the health sector due to inadequate supplies and poor working conditions, in addition to the persistent drain of skilled labour. The "health area" concept, which is conceived as a decentralised health care system able to integrate, at district level, the existing vertical programmes including preventive, curative and promotive activities, has been fully developed but not yet universally applied.

In the case of Yemen, and owing to its unification, the entire organisational set-up of the health system is in a stage of transition. There is a large public sector along with a sizeable private one. Also due to the absence of an adequate health information system, most available data are estimates. Problems of supplies and logistics affect most of the peripheral health care delivery network. Yet noticeable progress has been achieved in implementation of the health-for-all strategy in the Republic of Yemen. Segall and Williams (1983) analysed the interactions of socialist development policies, community initiatives, external influence, and planning processes and conclude that "*Health for All by the Year 2000*" in not an impossible goal for Democratic Yemen. Over the decade 1970-1980 the concepts of PHC in Democratic Yemen have progressively matured by a process of evolution. No longer confined to medical actions, the PHC in Democratic Yemen was broadened to encompass many health-related activities like the provision of safe water and the production and consumption of nutritious foods. When Segall and Williams (1983) made their assessment, PHC "package" in Democratic Yemen included MCH, environmental hygiene and provision of safe water, control of major communicable diseases, health education, management of common diseases and injuries, and referral of more complex problems; reporting on vital statistics and epidemics, and other basic items of health information. Yet, whether service provisions can be evenly distributed for the whole country remains to be seen.

In summary, the three countries' health strategies converge with minor differences in the degree of which elements are emphasised more than others.

1.8 The Structure of the Thesis

The aim of this thesis is to provide explanatory models of correlates of child survival in the Sudan, Egypt and Yemen and to identify higher-risk groups associated with combinations of correlates. Another aim is to assess the changes over time in mortality levels by comparing survival experience of recent births with those of earlier births. A third aim is to identify methodological gains, pertinent to country-specific findings, in extending marginal models commonly used to analyse child mortality to multi-level hierarchical models.

The thesis is divided into seven chapters. Following this chapter, Chapter Two presents a detailed description of the design and characteristics of the PAP-CHILD surveys. It also provides an assessment of the quality and validity of the survey data collected on the live births history, extensively used by the thesis.

Chapter Three provides a review of the concepts and methods in the analysis of child survival in relation to data requirements and empirical findings. The section on concepts outlines and discusses empirical findings of the associates of child mortality; bio-demographic and socio-economic and how they operate. A selective review of the methods used in analysing child survival is provided in aid of the description of the strategy and innovations of the thesis.

Chapter Four begins with an introduction to the analysis of child mortality via life table analysis, followed by the first model-based analysis by country. The analysis fixes a comparative model across countries; starting with the survey design-adjusted logistic regression model, followed by the Cox regression model (with time-varying covariates) and concluding with a comparative discussion of results of the two model-based analyses.

Chapter Five addresses the second model-based analysis; the use of multi-level models for the analysis of child survival for each country separately. The chapter concludes by drawing on the extensions of the multi-level results to those gained in Chapter Four.

Chapter Six collates the objectives of the thesis to serve two purposes. The first is a comparison of the model-based results for each country and the second a cross-country comparative discussion of key findings regardless of the methodology deployed. The chapter concludes by summarising the key findings emerging from the thesis.

Chapter Seven concludes the thesis restating its objectives and contrasts and reiterating principal findings. The chapter also reflects on methodological issues and data requirements, implications to policy aimed at improving child mortality in the three countries and future interest in the area of child mortality.

CHAPTER 2

INTRODUCING PAP-CHILD SURVEYS AND DATA QUALITY ASSESSMENT OF MATERNITY HISTORIES

2.1 Introduction:

During the second half of the past century, governments in many parts of the developing world have worked to increase the quantity and the quality of modern health services available to their populations. Before independence, most colonial governments introduced health programmes and that, with other aspects of development, such as increasing levels of education, led to improved child care practices and better utilisation of health services. Early attempts to measure mortality levels in the developing world were based on efforts to register all births and deaths through a vital registration system. Despite many attempts the coverage and quality of vital registration systems remain poor at the national level.

Most recent efforts to estimate mortality levels and trends at the national level are based on large-scale surveys and censuses. With the emergence of special-purpose surveys, using a representative sample of a population of interest, many researchers found it possible to investigate the demographic dynamics of many populations. Two prominent and influential surveys have been the World Fertility Survey (WFS) initiated in 1972 and conducted in 42 developing countries and the Demographic and Health Surveys (DHS), which continue today in their second and third phases. Since its initiation in 1984 and, during its earlier two phases, the DHS have assisted more than 50 countries in conducting national surveys on fertility, family planning, and maternal and child health.

These surveys employ two basic approaches to estimating infant and child mortality. The first approach involves direct methods, which are based on reported births and death of individual children collected by the maternity history. Collecting retrospective maternal live-births histories have formed the core of both the WFS and the DHS. Variations include truncated maternity histories, which include only recent births (i.e. children born during the past five years or the two most recent children born to each mother). Death rates can be calculated directly from these data because they follow tabulations of death and person years of risk at each age (Ewbank and Gribble, 1993).

Common shortcomings of data on child survival include the omission and displacement of births and deaths and misreporting of ages and durations of exposure to the risk of death (Ewbank and Gribble, 1993). Although the general impression of mortality decline is strong, the estimated trend would sometimes require caution because of these types of error in data.

The alternative approach is to use indirect methods, which are based on data that do not provide tabulation of deaths and person years of risk by age. The most common indirect approach is Brass's (1967) child survival method, which uses data on the average numbers of children ever born and the surviving children of women in each five-year age group, along with a simple model. This model requires assumptions about the age pattern of child mortality. It can be used to estimate trends in mortality on the further assumption that the trends in recent years have been smooth. Several variants of this model are described in detail in the United Nations Manual X (United Nations Department of International Economic and Social Affairs, 1983).

Expected are variations in the quantity and quality of the available data for the three settings. In addition to that, intra-country variations may arise in data quality.

Using WFS data which included Egypt, Jordan, Mauritania, Morocco, Sudan, Syria, Tunisia and Yemen, Farid (1984) observes that direct and indirect estimates of infant and child mortality during the twenty years prior to the survey are quite close only for Egypt. For the remaining countries, the indirect estimates are consistently and significantly higher than the direct estimates. In particular, direct estimates of mortality seem to have been depressed by the disproportionate omission of early infant deaths and by the misreporting of past infant deaths. Farid (1984) adds that the direct and indirect estimates of infant and child mortality seems to have been depressed by the omission of livebirths, especially those followed by an early neonatal death – a flaw most likely caused by the reports of older women about events that occurred considerably in the past. Also he observes that excess female mortality among children is commonly observed in societies with a moderate to high levels of child mortality and a preference for male children. Farid (1984) argues it is most unlikely that these sex differentials in mortality can be explained by reporting errors-when male children are preferred, they are less likely than girls to be omitted from the birth histories.

This chapter has multiple tasks of introducing the data sets to be used by the thesis plus the assessment of data quality. Section 2.2 introduces background information on the sample survey data to be used followed by Section 2.3 discussing issues concerning the accuracy of data reported in the live births histories. Section 2.4 pursues an extensive examination of the data quality and Section 2.5 concludes by the general comments on the data quality assessment exercise.

2.2 Objectives And Content of The Survey Protocols:

The League of Arab States (LAS) aimed at emulating the success stories of WFS and DHS, by their own initiative, The PAP-CHILD Survey. The PAP-CHILD survey (Pan-Arab Project for Child Development) was born out of a regional research programme undertaken by the LAS, with the Collaboration of the Arab Gulf Programme for the United Nations Development Organisations (AGFUND), the United Nations Population Fund (UNFPA), the United Nations Children's Fund

(UNICEF), the World Health Organisation, and United Nations Statistical Division (UNSTAT). These parties remain concerned with many objectives, two of which are;

- Upgrading the maternal and child health data bank through the provision of information generated from the survey that can be used in the evaluation of on-going maternal and child health programmes as well as in the identification of policies and programmes required to achieve the aim of *Health for All* by the Year 2000; and
- Providing detailed information on the status of women; and to increase the awareness of issues related to child needs, health, development and welfare through a series of publications and wide dissemination of the survey findings.

The life-cycle of the PAP-CHILD Surveys is typical of that found elsewhere with the WFS and DHS. The PAP-CHILD survey for Yemen, Yemen Demographic and Maternal and Child Health Survey (YDMCHS, 1991/92), is the first representative demographic sample survey in the case of Yemen post unification in 1990. The duration of the survey field work was between November 1991 and January 1992. Sudan, until this point in time, remains with the PAP-CHILD survey, SMCH (1992/93), as the latest representative demographic sample survey of the country (excluding the war affected regions of the Southern country). Because of the country's broad spatial distribution, logistical problems (shortage of fuel, cars and spare-parts) and the rainy seasons, the field work was executed governate after governate (Darfur taking the longest period and the Northern region taking the shortest period). The duration of the field work was between December 1992 and August 1993. Fieldwork for Egypt's PAP-CHILD survey, EMCH (1991) was carried-out during January to March, 1991.

A research package was designed to assist researchers in conducting the surveys at a national and sub-national level. They consisted of a general introduction, guidelines on study design, including sampling, model questionnaires, an interviewer's manual, a data management manual and guidelines on tabulation. Surveys were designed to collect data on households, ever-married women of reproductive age (under age 55) and children under five, respectively.

Surveys adopted a stratified, multi-stage sampling design. Samples were stratified by urban and rural classification of regional divisions or governates. In the first stage, primary sampling units (PSUs) or clusters were proportionally allocated and randomly selected among the strata; the second stage involved a random selection of about 30 households within PSUs. In the case of Egypt, a secondary stage of selection involved designating two standard segments of average size 500 persons within each PSU. The size of the cluster was 25 households on average. The samples of Egypt and Sudan are self-weighting. Urban and rural areas in the two regions – North and West, South and East, stratified Yemen's household sample. The initial objective of having a self-weighted sample was modified in order to have reliable estimates for urban and rural areas within each region. Sample weights were provided for analyses based at the household or woman level, separately.

The surveys consist of three main questionnaires. A household survey is conducted over a representative sample of households, with standard and relatively innocuous questions about the background of household member. The next step was to list all the household members and to identify women eligible for the individuals' detailed interview. A random procedure was established in the sample design to interview a sample of eligible women visited by the interviewers for a second time with the individuals' questionnaire. In the three societies considered the majority of the population are Muslims and hence childbearing is expected and only realised within marriage unions. The interviewer then revisits eligible women to collect more detailed data using a reproductive health questionnaire and identifies eligible children under age five for the third round Child's Health questionnaire. Table 2.2.1 below outlines the sections of each of the questionnaires conduced.

Table 2.2.1 Scope of the successfully completed PAP-CHILD Surveys

	Egypt	Sudan	Yemen
Household Questionnaire Household Roster; Education ; Economic Activity; General Mortality; Disability; Fertility and Child survival for ever married women under age 55; Orphan-hood	√	√	√
Housing Characteristics Questionnaire Housing: Cooking: Water: Lighting: Sanitation: Waste Disposal; Ownership of Objects and Assets	√	√	√
Total Number of Household	11,074	5,320	12,836
Reproductive Health (Women's) Questionnaire Respondents' Background; Marriage and co-residence Reproduction and Child Survival; Husbands' Background Antenatal care: Current Pregnancy; Maternal Care: The last five years Child feeding Cause of death for children who died Family planning and child bearing attitudes	√	√	√
Total Number of Respondents	9,073	4,528	5,687
Child Health Questionnaire General Child Care; Morbidity: Diarrhoea, Morbidity: other Illnesses Immunisation; Weight and Height ;	√	√	√
Total Number of Children	8,160	4,585	6,715

In the case of Yemen, in half of the selected households, only the "Household" and "Housing" characteristics questionnaires were administered. In the other half, the "Women" and "Child" questionnaires were also administered to all eligible women and children(YDMCHS, 1991/92, p.6). After the fieldwork, the questionnaires were edited at the central statistical office in each country and with similar strategies, data was coded, entered and processed. The comparative study of this thesis extracts maternity histories from the women's questionnaire together with some of their age and socio-economic background information (e.g. their level of education, their husbands' level of education, whether their husbands' occupation is in agriculture and their area of residence). Further, and from the housing questionnaire, information provided for dwellings where women reside on sanitation, access to clean water supply and access to electricity will be extracted.

Table 2.2.2: Background Characteristics PAP-CHILD Populations

	EGYPT EMCHS 1991	SUDAN SMCHS 1992/93	YEMEN YDMCHS 1991/92
Total Population (000)	58,194	21,5	11,3
Sample size (ever-married women ages 15-49)	9862	4869	5687
Urban Population (%)	48	35	21.4
Annual Natural increase (%)	2.4	2.8	3.1
Crude Birth rate (/ 1000 population)	29.2	42.6	52.6
Crude Death rate (/ 1000 population)	7.4	15.1	21.8
Indicators of Fertility Levels and Correlates			
Total Fertility Rate	3.9	4.5	7.7
Mean Number of children ever-born to women aged 45-49	6.0	7.4	8.1
Median age at 1st marriage	19.2	16.0	15.8
Any knowledge of contraceptives	99.6	69.5	60.2
Contraceptive Prevalence Rate (%)	47.1	9.9	9.7
Indicators of Mortality Levels and Correlates			
Infant Mortality Rate (IMR)ϒ	61.5	70	82.8
Under-5 Mortality Rate ϒ	84.8	113	121.8
Average duration of Breast-feeding (in months)	19.1	19.2	15.9
Diarrhoeal episode in the last 2-weeks (% of births)	13.4	29.0	34.4
Percentage of Children aged 12-23 fully-vaccinated	67.4	65.0	45.0
Percentage of women who are Illiterate (based on sample)	48.4	56.0	89.2

Source: PAP-CHILD Surveys Fact Sheets, based on survey estimates.
ϒ≡estimate of the period 0-5 years before the survey.

The impression gleaned from Table 2.2.2 is that Egypt has a leading position in relation to lower mortality and lower fertility figures. Indicators of fertility show that childbearing starts with early marriage, especially in Sudan and Yemen. The gap in use of contraceptive methods, measured by the contraceptive prevalence rate is outstanding; close to one in two women in Egypt uses a method of contraception compared to one in ten in Sudan and Yemen. Further, and with regard to the average duration of breastfeeding, Yemen shows a substantial loss of almost three months compared to duration estimated for Egypt and Sudan, which could be a consequence of higher child mortality rates.

Extraction of the data was more or less straight-forward given the standardisation in the coding of the questionnaire items. The prime concern in the sections to follow is with the quality of data in the maternity histories reported in the reproductive health survey.

2.3 Issues in Assessing Data Quality

One of the principal advantages of utilising birth histories in demographic surveys is the opportunity it provides for direct estimation of rates and trends of infant and child mortality. Near the end of the WFS, and greatly attributed to the comparative work of Rutstein and his colleagues, Hobcraft and McDonald, that the utility and robustness of direct estimates came to be fully appreciated (Hobcraft, McDonald, and Rutstein, 1983, 1984; Rutstein, 1983, 1984; and, Hobcraft, McDonald, and Rutstein, 1985).

The data quality examination in this section draws on prior work by Arnold (1990) on the quality of DHS-I birth history data and displacement of birth dates; and by Sullivan, Bicego, and Rutstein (1990) on the quality of WFS and DHS-1 mortality data; and by Curtis (1995) on the quality of data used for direct estimation of infant and child mortality in DHS-II surveys; and Marckwardt and Rutstein (1996) on the accuracy of DHS-II demographic data, respectively.

Hill's (1991) review of approaches to the measurement of childhood mortality, concluded that complete maternity histories generally provide good to excellent information on the level of mortality. Complete maternity histories also fulfil many requirements, the only shortcomings being imposed by relatively high costs and thus practical limitations on sample size, affecting the detail of trends and of geographic variations. Data quality depends on fieldwork quality, which in turn depends on careful questioning (Hill, 1991).

Broadly speaking the quality of maternity histories data remains sensitive to two properties; the survey design and respondents errors in reporting. Two types of bias can be introduced by poor survey design. The first type is the structural bias which is due to the design of the survey and questionnaire. One structural bias occurs when only women who survived to the interview time are included, hence no information is collected on the child mortality experience of women who have died. Since it is believed that the death of the mother increases the risk of death for her children, this selection bias is likely to reduce estimates of infant and child mortality (Curtis, 1995).

Another structural bias is a truncation of data in the past because only women up to a certain age (usually 49) are interviewed (for these data sets, women up to age 54 were also included). As a result, only births to women aged 35 would be included in the sample of births 15 years prior to the survey. Childhood mortality generally exhibits a U-or J-shaped relationship with maternal age at the time of the birth. Curtis (1995) argues that the magnitude of the bias will depend on the magnitude and form of the relationship between maternal age and childhood mortality in each population. The only direct control for truncation bias is to restrict the mortality of children to women below the maximum age available in the most distant period of interest. For example, under age 30 for periods up to 19 years before the survey. Curtis (1995) clarifies that this practice would mean discarding a lot of information concerning the most recent period and will not provide estimates of the total level of mortality in any period.

The second type of bias is the sample bias which occurs if the sample design systematically omits certain groups of the population, such as shantytown dwellers. Given that the sample is well designed and correctly implemented, and non-response is kept a minimum, this bias should not be a problem.

Sample design, size and the level of mortality in the population influence the sampling errors associated with estimates of mortality. Sampling errors are necessary to indicate the amount of variability associated with a particular estimate. Large sampling errors indicate that the estimate is not very precise and that the true population rate could be substantially higher or lower than the survey estimate. The sampling errors associated with mortality rates are influenced by the sample size in the survey, the sample design, and the level of mortality in the population since at lower levels of mortality a particular sample size will produce fewer death than the same sample size in a high mortality population (Curtis, 1995).

To reflect that on the data sets of concern, samples were selected in two stages and are self-weighting (with the exception of Yemen) to ensure constant high-quality samples. SMCH (1992/93) has used the same sampling framework and design employed with Sudan Demographic and Health Survey (SDHS-I, 1989/90). The latter was included in Curtis's (1995) assessment of sampling errors of DHS-II surveys. Similarly, the sample for EMCH (1991) drew on the sample sampling frame work and design as that of Egypt's Demographic and Health Survey (EDHS-I, 1989/90) – the latter also included in the same assessment. Curtis (1995) concluded that in the majority of DHS surveys, including Yemen's YDMCHS (1991/92), the relative standard error of the infant mortality rate is in the range of 0.04 and 0.08 (i.e. the S.E is between four and eight percent of the infant mortality rate). Curtis (1995) adds that at sample sizes above 4,500 births, which apply for the data sets of this study, there is very little variability across surveys in the size of the relative standard error of infant mortality rate. Further, the analysis to be undertaken with the livebirths histories will also involve adjustments for the survey design (discussed in greater detail in Chapter Three), namely producing *corrected* estimates of standard errors.

The second property is that of reporting errors. Reporting errors refer to respondents' giving missing or inaccurate reporting to questions, such as mis-reporting of the age at death, and omission of births and deaths. Ignoring cases with missing information would cause downward biases in childhood mortality rates because typically information on the year and month of birth is more likely to be missing for children who have died than for children who are still alive (Sullivan, Bicego, and Rutstein, 1990). Most commonly, when the year or month of birth is missing, a value is imputed using a standard imputation procedure (Institute for Resource Development, (IRD, 1987). The three surveys allowed "season of birth" as an acceptable response. Responses in which the season is given are coded as "month missing" but imputation is over a 3-, 4-, or 12-month window depending on the season recorded. Initially, the Egyptian EMCH (1991) most respondents who provided "season of birth" as a response, were able to provide a month of birth when probed in the second survey, or that interviewers used the season of birth to estimate the month of birth. Responses in which an Islamic month was given are coded here as "month given" but the Gregorian months involves imputation over a 2-month window. The imputation procedure uses other information reported by the respondent to establish a logical time-period in which the birth probably occurred and then randomly assigns a date within that period. Thus, the impact of missing date-of-birth information on mortality rates and trends is expected to be small. This is particularly true if only the month of birth has been imputed because imputation then occurs within a one-year range (Curtis, 1995).

Missing information on age at death causes problems because it is not possible to determine the allocation of the death and the exposure in the calculation of mortality rates. An imputation process was used to reduce exclusion of births with missing data, which uses a *hot-deck* procedure; specifically, the missing age at death is assigned the value from the last dead child with the same birth order in the data file.

If omission of the age at death is systematically related to the age of death of the child, this imputation process could induce some distortion in the age pattern of mortality, although the overall under-five mortality is likely to be unaffected (Curtis, 1995).

Complete responses will not be spontaneous dispensers of accurate responses. Errors may occur because the respondent does not know the answer to the question and hence the response represents either her best guess, the interviewer's best guess, or some outcome of negotiation between the respondent and the interviewer. Curtis (1995) asserts that systematic misreporting of the birth dates of children would affect trends in mortality even if it were independent of survival status.

When births are moved forward in time, in a context of declining mortality rates, mortality rates will tend to be overestimated for the periods in which they were moved and visa versa. Curtis (1995) argues that if misplacement is related to the survival status of the birth, mortality levels and trends would be affected but the direction and magnitude of the bias would depend on the nature and extent of the differential displacement.

A typical example is the displacement of birth from the fifth to the sixth calendar year prior to the survey, which has been noted in several DHS-I surveys (Arnold, 1990). The consensus is that the displacement is linked to the health section of the questionnaire, which includes a number of questions asked of each birth occurring after a cut-off date – usually January 1st of the fifth calendar year before the start of the survey. The potential for bias in mortality rates will depend on the level of displacement and whether or not it is related to the survival status of the birth. If surviving and dead births are displaced equally there will be little effect on mortality rates in either period and hence little effect on mortality trends. If dead children are displaced more frequently, as occurred in several DHS-I surveys, Sullivan, Bicego, and Rutstein (1990) state that infant and child mortality will be underestimated for the most recent period and overestimated for the earlier period. The opposite will occur if surviving children are displaced more frequently.

Probably the most serious form of response error for the calculation of childhood mortality rates is omitting children who have died from the birth history. Omission is believed to be more common for children who died shortly after birth, sometimes to the sex of the child and to other characteristics of the mother and the child, which could distort trends in mortality (Curtis, 1995).

One further data accuracy issue is related to digit preference in date reporting, an example of which is in reporting of age at death as 12 months (and multiples of 12). Using a model that redistributed 25 per cent of excess death at 12 months to infancy, Sullivan, Bicego, and Rutstein (1990) concluded that adjusting the infant mortality rate for heaping at 12 months increased the rate by about five per cent in sub-Saharan Africa and about two percent in other regions. Taking these issues into consideration, the following section is an exercise of quality assessment of the maternity histories data to be utilised by the thesis.

2.4 Assessing PAP-CHILD Maternity Histories Data

The quality of data collected in the birth history section of the individual interview is of enormous importance for the calculation of levels and trends of infant and child mortality. For all surveys, the PAP-Child Project followed the same data sampling and collection protocol, with identical questionnaire designs, to that of DHS, particularly with the collection of full birth histories. To begin with, respondents' current age was the principal criterion used to determine the eligibility for the women's individual interview, and hence it is important to assess the quality of age reporting in connection with the household interview. Earlier studies of WFS and DHS-I surveys have indicated that age misreporting occurs more frequently for age groups at the boundaries of eligibility (Marckwardt and Rutstein, 1996).

Once more interviewers maybe tempted to reduce their work load by pushing women out of the eligible age range in order to reduce the number of women that have to be interviewed. There are several way to detect mis-reporting, displacement and distortions in reporting *"de facto"* status ; Marckwardt and Rutstein (1996) offer a few options. They pose the question about the probable effects of misreporting ages at boundaries of eligibility or of mis-reporting the overnight residence of women on the measurement of vital rates. They argue, from a theoretical standpoint, it can be assumed that the effect of displacement at the boundaries of age eligibility would be quite small, since fertility levels for all-women samples at ages 15-19 and 45-49 are generally low. Based on DHS-1 data, Rutstein and Bicego (1990) carried-out simulations that estimate the effect of lower boundary, upper boundary, and "sleeping away" exclusions on fertility rates and under-five mortality rates. The significance of the simulations by Rutstein and Bicego (1990) is that the gains made in DHS-II in the reporting of the *"de facto"* status (i.e., in reducing "sleeping away" exclusion) probably far outweigh the effects of increasing displacement at the border of eligibility. In the three surveys, only ever-married women age 15-54 who were usual residents of the household were interviewed (a *"de jure"* sample) with the individual questionnaire.

The data analysed in this thesis comes from the reproduction section in the individuals' questionnaire where the mother was asked to report all live births, including births of children who have died, first in terms of aggregate number of children ever born (CEB), then in terms of specific questions about each live birth (birth history). The birth history data are collected in chronological order, starting with the first birth and ending with the most recent. Data are collected on the date of birth, sex, survivorship status, current age and whether the child is living with the mother (for living children), and age at death (for dead children), as in the DHS-I surveys.

Specific rules are usually applied to the collection of data on the date of birth (year and month), current age, and age at death in DHS surveys. In the case of year of birth, current age, and age at death, the rules state that a date or age must be recorded (i.e. the code of "don't know" is not acceptable). In the case of month of birth, the rules for data collection are less stringent. As a last resort, it would be acceptable to record the code for "don't know" when no reliable response can be obtained. Instructions are usually included at the end of the birth history in virtually all DHS surveys reminding the interviewer to check recording the year of birth for all births, the current age for all living children, and the age at death for all dead children. Unfortunately, none of the PAP-CHILD surveys of the countries under study included these instructions at the end of the birth history. Most of the key assessments to follow mostly involve births born in the period 0-15 years before the survey, which will be directly used by the analyses of the thesis.

2.4.1 Distortions at the Boundaries of Age Eligibility

The first issue to be tested is whether there are signs of distortion at the boundaries of the age eligibility of mothers. The three surveys increased the upper bound of age eligibility to 55 years and hence the displacement in the age group is from 50-54 into 55-59.

Table 2.4.1: Indicators of quality of age reporting in the household questionnaire, World Fertility Survey (WFS), Demographic and Health Surveys (DHS), 1974-1993 and PAP-CHILD Survey (1991-1993)

	Age Ratio Among the Women				Sex Ratios			
Survey and Region	10-14	15-19	45-49	50-54	10-14	15-19	45-49	50-54
[a]WFS SURVEY								
Sub-Saharan Africa	93	93	82	137	105	96	110	76
Asia/NearEast/ N.Africa	103	101	94	112	106	98	106	96
[a]DHS-I SURVEY								
Sub-Saharan Africa	105	86	82	146	97	106	109	65
Asia/NearEast/ N.Africa	102	102	89	123	103	99	104	84
[a]DHS-II SURVEY								
Sub-Saharan Africa	108	88	72	144	96	105	103	72
Asia/NearEast/ N.Africa	103	99	89	119	108	100	108	86
PAP-CHILD SURVEY	10-14	15-19	50-54	55-59	10-14	15-19	50-54	55-59
Egypt (EMCHS, 1991)	109	94	75	115	109	116	116	74
Sudan (SMCHS,1992/93)	99	106	65	120	106	97	154	68
Yemen (YDMCHS1991/92)	101	92	53	173	113	96	141	52

a Marckwardt and Rutstein (1996) figures are unweighted means of ratios for countries in each region and for those countries where the limiting age groups for eligibility were other than 15-19 and 45-49, the appropriate ratio have been substituted.

A high age ratio at 10-14 in conjunction with a low age ratio at 15-19 is very suggestive of displacement. There may be some interviewers who may be reluctant to interview the often sexually inactive younger adolescent daughters of respondents who they have already interviewed, especially if parents are present (Marckwardt and Rutstein, 1996). The pattern, in the case of Sudan, is somewhat reversed, suggesting that more women were pushed into the lower boundary of age eligibility band. If the difference in age ratios of 10 points or more between adjacent age groups is taken as a criterion for displacements, then there seems to be a slight displacement at the lower boundary of age eligibility for Egypt and perhaps marginally for Yemen.

With the age group 45-49 as an upper bound, Marckwardt and Rutstein (1996) observe the most serious problem is found in the sub-Saharan region, with differences of 50 or more points in all the three survey programmes (WFS, DHS I, DHS II). In the case of Egypt, the amount of displacement appears slightly higher than the regional average from the previous three surveys. In the case of Sudan, the amount of displacement resembles that of the sub-Saharan regional average. Concern is more serious with the amount of displacement found for Yemen. A problem which would be further aggravated by the high illiteracy and preference for digits ending in 0 and 5 amongst those older groups (YDMCHS, 1991/92). Marckwardt and Rutstein (1996) also examined the sex ratios of the four age groups defining the boundaries of eligibility. Though this indicator is less discriminating, a high sex ratio (number of males divided by females times 100) at ages within the boundary of eligibility coupled with a low sex ratio at ages outside the boundary of eligibility would be suggestive of sex-selective displacement. The sex ratio presented as part of Table 2.4.1 tend to confirm the pattern identified by Marckwardt and Rutstein (1996) and the conclusion drawn from the age ratios of women. At the lower bound, displacement inside the eligibility criteria (15-19) is suggested for Yemen and Sudan (the latter following a similar pattern found in North Africa for all surveys). The trend for Egypt is rather puzzling – resembling that of sub-Sahara Africa. At the upper bound, the displacement is similar to that identified by Marckwardt and Rutstein (1996) which is quite severe in the case of Sudan and Yemen.

2.4.2 *Dates of Birth of Children*

One of the ways of evaluating the accuracy of information on children's birth dates is to examine how completely these dates were reported in the birth histories and how many birth date responses were missing information that had to be imputed. Table 2.4.2a presents the percentage of births with incomplete information on date of birth by survival status, for each country. The denominator of the percentages is births with a date of birth (reported or imputed) during the 15-year period prior to the survey. For both living and dead children, Sudan and Yemen present high percentages of births with missing information on month of birth, which, in turn, is due to the fact that "season of birth" was treated as an acceptable response in these two surveys. For these cases, imputation of month of birth is within a range of only three or six months.

The originally coded "date of birth" variable had not been provided with the Sudan birth histories data set. To assess the level of imputation for that data set, birth history entries were linked with the household roster file, using their mothers number and matching as close as possible their individual numbers in the household roster to their birth order. This was quite rewarding in providing a close-to-perfect assessment of the level of imputation of children's "date of birth", shown in Table 2.4.2a. This process showed that about 5 per cent of children reported dead required imputation of "year of birth" compared to 0.5 per cent of children reported alive; and overall half of all births entries required imputation of the "month of birth".

Table 2.4.2a: Percentage of births **0-15 years** before the survey with incomplete information on date of birth by survival status, PAP-CHILD surveys

	Living Children		Dead Children		All Children
Region and Survey	Month Only Imputed	Year and Age Imputed	Month Only Imputed	Year Imputed	Anything Missing
Egypt					
(EDHS-I, 1989/90) [1]	27.1	0.0	63.7	1.7	32.5
(EMCH, 1991)	21.8	0.1	60.3	0.5	26.4
(EDHS-II, 1992) [1]	8.4	0.0	31.7	0.3	11.1
Sudan					
(SDHS-I, 1989/90) [1]	38.5	0.0	59.8	1.2	41.5
(SMCH, 1992/93) [2]	51.3	0.5	52.5	4.9	51.4
Yemen					
(YDMCHS, 1991/92) [1]	42.9	0.1	54.3	4.8	45.4
(YDMCHS, 1991/92) [3]	38.0	0.1	55.7	4.9	40.5

1 = From Curtis (1995), page 26.
2 = Level of Imputation deduced from the Household Roster data file.
3 = Assessment using sampling weights.

Using Curtis (1995) comparisons one can observe that the completeness of date-of-birth information for Egypt (where two DHS surveys were being assessed at the time) shows substantial improvement that is primarily due to increased reporting of month of birth. Whilst the situation appears unimproving comparing Sudan's SDHS-I (1989/90) with SMCH (1992/93).

For Yemen, two assessments are shown for the same data set; the first comes from Curtis's (1995) assessment, which provided unweighted estimates. Carried-out by this study, the second assessment incorporates sampling weights that were provided for Yemen for women aged 15-54. In general, both assessments agree quite well, showing that about 5 per cent of children reported dead required "year of birth" imputation compared to virtually none for living children. Imputation of "month of birth" was needed for about two in five children alive compared to one in two children dead.

Overall, the percentage of living children missing information on date of birth is substantial in the case of Sudan (51 per cent) and Yemen (38 per cent). Nevertheless in all surveys the percentage of living children missing year of birth (and current age) is close to zero.

Further examined is the completeness of "age at death" reporting shown by Table 2.4.2b. below. Sudan has the lower percentage of age at death reporting compared to the other two countries with virtually no difference between urban and rural residence reporting and slightly better reporting of males deaths compared to female deaths.

Table 2.4.2b: Completeness of age at death before age five reporting of **births 0-15 years** before the survey by Gender and Area of Residence surveys

Region	Total Number of Deaths Reported	% with age at death reported in months	% with age at death reported in months Urban Areas	% with age at death reported in months Rural Areas	% with age at death reported in months Males	% with age at death reported in months Females
Egypt	6272	94.1	93.9	94.2	94.5	93.7
Sudan	2938	88.0	88.0	88.0	88.9	86.8
Yemen	4872	93.1	92.4	93.3	92.9	93.4

What seems impressive to observe is the comparable percentage of completed dates for the cases of Egypt and Yemen, despite lower levels of female literacy in the latter.

2.4.3 *Distortion at the Five-year Window*

Arnold's (1990) review of DHS-1 surveys showed displacement of births from the fifth year prior to the survey to the sixth year that occurred in DHS-1 surveys. He found the amount of displacement to be highest in sub-Saharan countries, somewhat lower in North African and Asian countries, and to be least in the Latin American and Caribbean countries. For all three regions, the amount of displacement of dead children was significantly greater than for living children. With the increase of questions in the health section of DHS-II surveys, Arnold (1990) predicted that the problem of displacement would increase.

Marckwardt and Rutstein (1996) showed slightly more displacement in DHS-II than in DHS-I. They used a birth-year ratio which is equal to the number of births x years before the survey divided by one-half of the sum of the number of births in the years x-1 and x+1 prior to the survey. If there were no displacement, the ratios for both years five and six would be close to 100. If there is backward displacement in time (from year 5 to year 6), the ratio for year 5 will be less than 100 while that for year 6 will be greater than 100, also indicating displacement of births out of the period covered by the health section of the questionnaire. The difference between the ratios can be taken as an indication of the magnitude of the displacement. Table 2.4.3. illustrates birth year ratios centred on the number of births in years 5 and 6 before the survey. Marckwardt and Rutstein (1996) also showed displacement was greater for dead children than for living children as with DHS-I.

Table 2.4.3 Birth Year Ratios by Child's Survival Status, DHS and PAP-CHILD Surveys:

	Centred on Five years			Centred on Six years		
Survey and Region	Dead	Alive	All	Dead	Alive	All
PAP-CHILD Surveys						
Egypt (EMCHS, 1991)	100	98	98	103 (3)	102 (4)	102 (4)
Sudan (SMCHS, 1992/93)	70	71	71	129 (59)	120 (49)	121 (50)
Yemen (YDMCHS, 1991/92)	76	79	79	108 (32)	122 (43)	120 (41)
[a]Sub-Saharan Africa						
DHS-I	81	89	87			120 (33)
DHS-II	78	89	87			117 (30)
Sudan (SDHS-I, 1989/90)	68	91	87	158 (90)	110 (19)	117 (30)
[a]Asia/ Near East/ N. Africa						
DHS-I	87	95	94			105 (11)
DHS-II	76	88	88			116 (28)
Egypt (EDHS-II, 1992)	76	97	95	125 (49)	109 (12)	110 (15)
Yemen (YDMCHS, 1991/92)	83	77	78	109 (26)	123 (46)	121 (43)

a Marckwardt and Rutstein (1996) Birth year ratios by survival status of the child, Demographic and Health Surveys, 1989-1993; Numbers in blue present differences in ratios.

Table 2.4.3 represents figures produced by Marckwardt and Rutstein (1996); their study shows that there was slightly more overall displacement in DHS-II than in DHS-I. In the case of the Sudan, the disparity grew from 30 (117-87) in SDHS-I (1992/93) to 50 (121-71). Marckwardt and Rutstein (1996) have used number of births by calendar year preceding the survey, while this study uses the number of birth born 0-11, 12-23,24-35,...months instead, so it might be their figures are slightly overestimating the number of births in year 5. In the case of Yemen, the size of the disparity is 41 compared to 43 found by Marckwardt and Rutstein (1996) on the same data set. The absolute effect of displacement for Egypt is somewhat better for EMCH (1991) compared to the later EDHS-II (1992). Comparing the two surveys, as reported in Table 2.4.3, the differences in ratios are 4 (102-98) and 15 (110-95), respectively.

The probable effects of displacement on birth rates and demographic estimates depends on the magnitude of the displacement, the timing of the survey, and the period or periods for which estimates are made (Marckwardt and Rutstein, 1996). The problem will obviously be less serious if births are being moved backward in time by a few months rather than a whole year. The effect will also be less serious for surveys conducted near the end of a year than for those carried out early in the year (Arnold, 1990 : p.93).

Like the DHS, PAP-CHILD included a detailed section on maternal and child health for births born in the last 5-years. The section carries a number of sub-sections and a considerable number of extra questions, which could tempt interviewers to push births further to the sixth year before the survey, hence reducing their workload. The "maternal care: last five years" section included about 47 questions for all three surveys so the burden of questions is the same. Marckwardt and Rutstein (1996) showed that displacement of births in DHS-II was not even greater given the growth in the number of questions in Section 5 (the maternal care: last five years section) of the questionnaire.

2.4.4 Omission versus Displacement

Data quality assessment studies seem to agree that the same motivation that drives interviewers to displace children out of the reference period for the maternal care in the last five years section of the questionnaire could also tempt them to omit a recent birth altogether. Displacement causes a peak at the sixth year, followed by an immediate return to the average number of annual births. A sudden drop evidences omission at year 5 before the survey but no recovery in the nearer future. While it seems fairly easy to detect displacement and to adjust the reporting periods of vital rates accordingly, there is no way to salvage the complete omission of a birth in the five years preceding the year of interview (Marckwardt and Rutstein, 1996).

Fig. 2.4.4a Number of Births by Year Prior to the Survey by Country

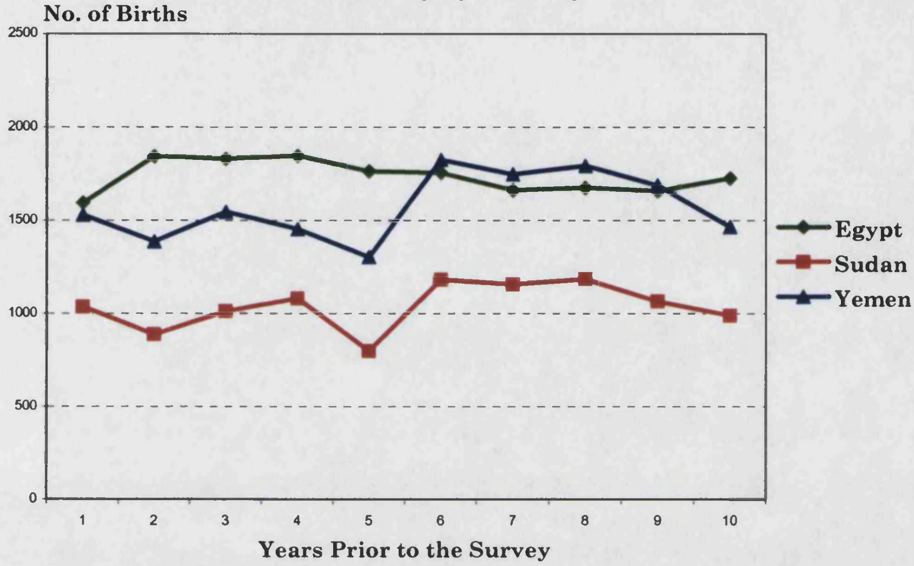


Fig. 2.4.4a above displays a typical curvilinear appearance of the number of annual births plotted against the sequential calendar year prior to the survey. Egypt shows no observable evidence for displacement or omission, whilst the pattern for Sudan and Yemen are almost identical, with Yemen showing high fertility levels. The general trends pointing towards more displacement than omission, evident by the dip at the fifth year, followed by an immediate return to the average number of annual births. If there were omissions then it would be evidenced by a sudden drop at year 5 before the survey but no recovery in the nearer years.

For Sudan, the mean number of births for years 1 to 5 prior to the survey was, 962, a 14 per cent drop from the 1114 recorded for years 6 to 10. Sudan is showing moderate omission maybe improving on the situation compared to SDHS-I (1989/90). This assessment calculates the drop for Yemen as 15 per cent. Using the same data set, Marckwardt and Rutstein (1996) believe the drop for Yemen in the most recent period was intermediate, a fall of 19 percent. In Yemen, the interviewers were asked to collect information on children born in the last five years, rather than including children through the fifth calendar year as in the other DHS surveys. Consequently, the boundary for Yemen is between 4 and 5 rather than years 5 and 6 prior to the survey (Marckwardt and Rutstein, 1996). One could speculate the curve for Yemen might also be suggestive of a subtle decline in fertility for the more recent 5-year period.

Marckwardt and Rutstein (1996) examined 25 DHS-II surveys, and in their analysis, and although these matters are highly subjective, their opinion is that Sudan is amongst nine showing signs of substantial displacement, Egypt is amongst four countries showing moderate displacement and Yemen is amongst three showing evidence of substantial omission.

The use of sex ratio at birth for individual countries can also be used to assess selective omission. Figure 2.4.4b, shows the overall sex ratio of males to females for the three countries. The patterns in the cases of Sudan and Yemen appear quite erratic with no clear trend in the sex ratio from one birth year to the next.

Fig. 2.4.4b Sex Ratio at birth by Country and Years Prior to the Survey

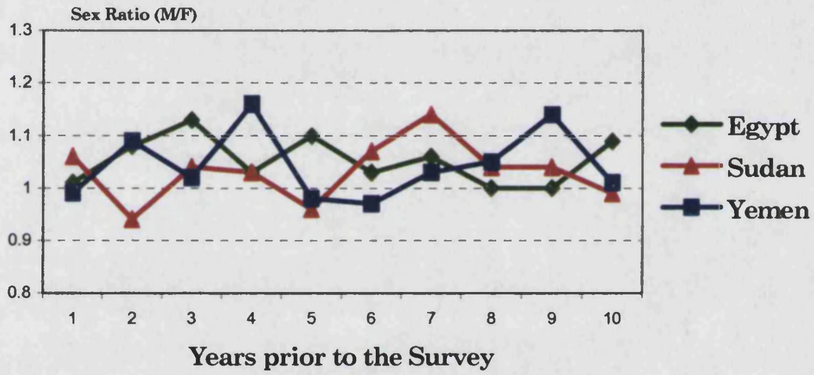
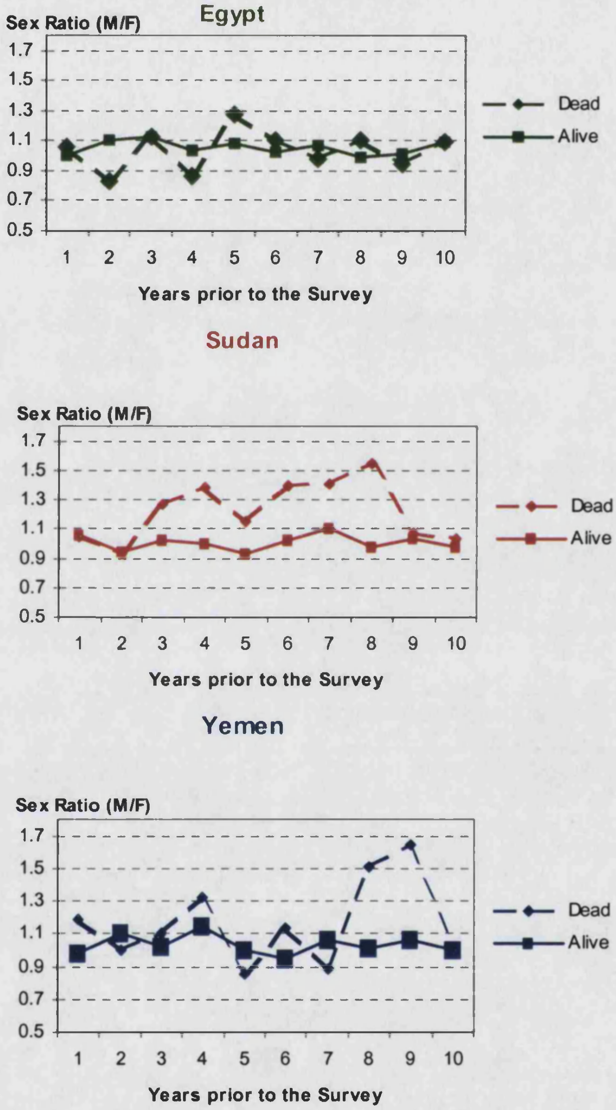


Fig. 2.4.4c below depicts the sex ratio (Male/Female) at birth by survival status for the ten-years period preceding the survey date. The pattern for Sudan is rather worrying with persistent omission of dead female births compared to their counterparts. The trend in Yemen is once again erratic, perhaps with severer omission of death females further back in time (eight or more years before the survey). The pattern for Egypt is quite interesting. Further back in time, six or more years before the survey, the sex ratio for dead and alive children hovers over unity. Yet the in the five years period before the survey, the pattern starts by a clear rise in the sex ratio signalling omission of dead female births and then oscillates above and below unity from one year to the next, closer to the survey time.

Figure 2.4.4c Sex Ratio at birth by survival status and Years Prior to the Survey



2.4.5 *The Calculation of Childhood Mortality Rates:*

The prime reason for collecting good quality and complete maternity histories in demographic and health surveys is to provide for the direct measurement of rates and trends of childhood mortality and fertility. A more pervasive problem almost universal in developing country surveys is the tendency to round ages at death of children to exact numbers or convenient fractions of years.

Reporting on infant deaths is commonly tallied only for those dying during months 0-11 following birth. Rounding of ages at death up to the 12th month will cause infant mortality to be underestimated and early child mortality to be overestimated. However estimates of under-5 mortality will not be affected (Marckwardt and Rutstein, 1996). One way to investigate rounding of ages at death is by an index of heaping, which can be calculated with the numerator equal to 4 times the deaths recorded at 12 months, and the denominator consisting of deaths recorded at ages 10,11,13 and 14 months, respectively. Ideally, this index, called the "age ratio" should equal unity. Recent innovations in questionnaire design help by lessening the heaping of deaths and hence improving data quality. For age at death reported as 12 months, interviewers are instructed to probe to determine exact number of months – they are reminded to do so by a check box at the bottom of the live-birth history. Once again, that check box was missing in the PAP-CHILD surveys. Compared to earlier surveys, the median index of heaping (for 0-24 years before survey) was 5 for the DHS-II surveys (Curtis, 1995), and 11 for DHS-1 surveys (Sullivan, Bicego, and Rutstein, 1990) and in the assessment of WFS data (Goldman, Rutstein, and Singh, 1985; Curtis, 1995).

Table 2.4.5a Index of heaping at 12 months of age at death by period in which the death occurred, PAP-CHILD surveys.

	Years preceding the survey					
Country	0-4	5-9	10-14	15-19	20-24	0-24
Egypt[1]	36.0	38.8	34.6	33.2	34.3	35.7
Sudan	14.9	16.8	16.0	20.3	16.7	19.5
Yemen[2]	11.9	23.2	10.5	19.1	15.6	14.8
Yemen[3]	15.6	14.5	13.7	17.2	16.9	15.1

Notes:

The index of heaping is calculated as $(4^*D_{12}) / (D_{10}+D_{11}+D_{13}+D_{14})$; The period in which the death occurred is derived from the date of birth, the imputed age at death in months and the date of interview.

1 : Egypt shows zero deaths reported between ages 13 and 23 months.

2 : Curtis, 1995 : page 36.

3 : Using Sampling weights.

Table 2.4.5a reflects considerable levels of heaping at 12 months of age especially for older births cohorts in Egypt and Sudan. For Egypt, the coding of age at death shows no ages at death were reported between ages 13 and 23 months, hence the index of heaping calculated is not a reasonable test. The index of heaping in the case of Sudan is quite considerable (considering the whole period 0-24 years before the survey); but the estimates show an improving trend for more recent cohorts.

Whilst in the case of Yemen, weighted or otherwise, the trend of lesser heaping with time is unclear.

One way to investigate the implications of heaping age at death at 12 months on estimates of infant mortality rates are shown by Table 2.4.5b. Mortality rates are adjusted by reassigning 25 percent of the "excess" deaths at 12 months back to the 6-11 month age segment. Excess death are calculated by the difference between the number of death at age 12 months and the average number of death at months 10, 11, 12, 13, and 14. With that adjustment and in the three samples, unadjusted infant mortality rates have increased by less than 5 per cent, which is perhaps within the boundaries of the usually calculated standard error estimates.

Table 2.4.5b Infant and child mortality rates for the period 0-9 years before the survey, adjusted for heaping of births at twelve months of age, PAP-CHILD surveys.

	Infant Mortality rate ($_1q_0$)			Child Mortality rate ($_4q_1$)		
Country	Unadjusted Rate	Adjusted Rate	Percent Increase	Unadjusted Rate	Adjusted Rate	Percent Decrease
Egypt	82.1	85.7	4.4	32.8	29.0	11.6
Sudan	79.9	83.3	4.3	52.9	49.4	6.6
Yemen	103.5	107.3	3.7	41.3	37.2	9.9

Note: Mortality rates are adjusted by reassigning 25 percent of the "excess" deaths at 12 months back to the 6-11 month age segment. Excess death are calculated by the difference between the number of death at age 12 months and the average number of death at months 10, 11, 12, 13, and 14.

Under-five mortality rates for the period 0-9 years before each survey were also adjusted for heaping at 12 months. Findings agree with those of Curtis (1995) and as expected, this adjustment had virtually no effect on this rate. Perhaps the best solution from an analytical stand point, is for the analysis to build more on mortality under age five which should be unaffected by heaping of age at death 12 months.

2.5 Conclusion:

This assessment of the data quality of the live-births histories shows no gross errors of the type to vitiate substantive analyses. In general, there was evidence of birth displacement, and differential displacement by survival status especially in the cases of Sudan and Yemen. Comparing Egypt's data for the three surveys EDHS-I (1989/90), EMCH (1991) and EDHS-II (1992), this assessment shows considerable gains in improvements in age at birth reporting, age at death reporting and reductions in shifting or omission of births. In the case of Sudan, not much improvement in data quality can be reported between (SDHS-I, 1989/90) and SMCH (1992/93). With the Yemeni data the study misses-out on not readily having a benchmark of comparison but perhaps a future comparison with YDHS (1997) could better reflect improvements of data quality with time.

What was noted is the that PAP-CHILD surveys missed out in including instructions at the end of the birth history to remind the interviewer to check the year of birth for all births, the current age for *all* living children, and the age of death for *all* births were recorded. Critical instructions as those, coupled with appropriate training should reduce the incidence in incomplete date reporting in future PAP-CHILD surveys.

Displacement of women and children birth data was considerable in Sudan and Yemen perhaps due to interviewers being forced to make more estimation of ages and birth dates, hence providing them with more opportunity to lessen work load. Training should emphasis careful probing and perhaps seeking better quality interviewers.

Resorting to de facto enumeration (i.e., in reducing "sleeping away" exclusion) in PAP-CHILD surveys would reduce exclusion of women and may perhaps reduce the shifting in eligibility criteria. Demonstrated by the simulations of Rutstein and Bicego (1990), gains in using "de facto" status probably far outweigh the effects of increasing displacement at the border of eligibility.

Missing from PAP-CHILD surveys, the assessment of DHS-I data for direct estimation of infant and child mortality included a recommendation for the inclusion of a specific box at the end of the birth history where interviewers are required to check that any age at death given in 12 months had been probed (Sullivan, Bicego, and Rutstein, 1990). Marckwardt and Rutstein (1996) report the impact of this innovation is questionnaire design was particularly noticeable for sub-Saharan countries where the amount of heaping at age 12 months was cut by 75 per cent comparing DHS-I with DHS-II – for Asia / Near East / North Africa heaping was cut by 37 per cent.

Although the increased length of the health section probably explains the persistence of the birth displacement in DHS-II surveys, it does not fully explain why dead children are displaced more frequently. Curtis (1995) gives one explanation for the higher level of displacement of dead children could be that respondents are less able to provide a year of birth for a dead child, at least in part because they do not have current age to work from. Hence, interviewers are more likely to have to estimate the year of birth for dead children, making it easier for them to displace a child to before the period covered by the health section. Training in field procedures is instrumental.

Differentials in displacement of births by survival status have implications for the estimation of mortality rates, although its impact is relatively modest (Curtis, 1995). Increased emphasis on this issue in training was recommended by Sullivan, Bicego, and Rutstein (1990) as was the use of field-check tables to identify the problem at an early stage. However, these measures do not appear to have been effective in reducing the problem.

Selective omission of deaths events persists in the case of Sudan and Yemen. In an attempt to reduce the omission of events the DHS-III core questionnaire includes an additional question in the birth history of each child (except for the first one) which specifically probes for omitted birth in intervals where the difference in the year of reported year is more than four years. Curtis (1995) adds this an extremely difficult problem to identify with confidence and is likely to persist some time in populations in which knowledge of ages and dates is poor.

If PAP-CHILD surveys were to follow the course of DHS-II surveys in increasing the number of questions pertinent to the maternal and child health section, further problems of interviewer-imposed displacement may further arise. Marckwardt and Rutstein (1996) make the observation that since the burden of these in the DHS-I survey was already sufficient to induce certain interviewers to cheat when estimating or recording children's ages, the additional burden in the DHS-II survey did not cause additional interviewers to do so

While it is assumed that imputation process introduces no bias into the distribution of birth over time, it is obviously preferable when respondents are able to report both the month and year of birth. Better still if respondents are probed to make their own imputation or if interviewers could make their own imputation! On the whole and to minimise effects due to reporting errors, only births born in the period 0-15 years before each survey time will be deployed in the analysis to follow. This would reduce any concern arising from using earlier and probably more erroneous births data.

CHAPTER 3

CONCEPTS OF CHILD SURVIVAL AND STRATEGY OF ANALYSIS

3.1 Measuring Childhood Mortality

The analysis of child mortality requires careful thought, since the risk of death varies with age and since the analyst seldom has complete information on a set of individuals observed from birth until death (Trussell and Guinnane, 1993). When studying mortality two events need to identified: a birth event and a death event (a terminating event); the period between these two events is of interest to demographers. Conventionally a sample of live births is sub-divided into categories, which roughly reflect changes in the probability of dying and changes in the main causes of death, which occur during the first five years of life.

Four categories of ages at death before age five are widely used; the first month (neonatal), the remainder of the first year (post-neonatal), the second year, and the third to fifth years. The probability of dying is at its peak at the time of birth (including the period immediately before birth) and declines thereafter, except perhaps for a minor peak when the child is weaned. Broadly speaking, between the twenty-eight week of gestation and the end of the first week of life, the underlying causes of death are principally complications of the pregnancy and delivery, and poor maternal health and nutritional status. After the first week of life diarrhoeal diseases and respiratory infections become leading causes of death, with under-nutrition often an underlying cause. Infectious diseases of childhood begin to appear in the second half of the first year of life and, combined with poor hygiene, may result in high case-fatalities. Succinctly, deaths of children aged one to four years are mainly a product of environmental factors, including nutrition - as such they provide a sensitive indicator of the socio-economic conditions under which the household, or at a greater scale the community, dwells.

As mentioned earlier in Chapter One, harder to determine are causes of death among children because of the commonly unreliable national systems of death registration. In addition, knowledge of the cause of death is hampered by the fact that many deaths have multiple causes and in many circumstances are lacking accurate diagnosis. Perhaps the closest profile to the three localities in question is that identified by Ewbank and Gribble (1993) for African childhood mortality; which also includes Sudan. With limited data, they observe the leading causes of death during the neonatal period are birth trauma, prematurity, and congenital defects, although tetanus was the leading cause of death in a few studies. In the postnatal period, diarrhoea appears to be the leading cause of death, followed by Acute Lower Respiratory Infection (ALRI)- pneumonia. Among children aged 1-4 years, measles, diarrhoea, ALRI, malaria and malnutrition are the leading causes of death (Ewbank and Gribble, 1993: p.25). A variety of nutrition-related conditions exacerbate the mortality effect of several diseases. Protein-energy malnutrition, common among children between 6 and 23 months of age, is associated with increases in diarrhoea and other diseases. Variations exist in the prevalence of malnutrition in the region of concern, and a number of studies suggest that the effect of nutritional status is less important in African than in Asia. Mild and severe vitamin A deficiency seems to be associated with excess mortality. Again, little evidence exists to make conclusions about the effect of vitamin A supplementation in sub-Saharan Africa (Ewbank and Gribble, 1993: p.131).

It follows that different biosocial and bio-demographic factors influence different age segments, either as direct effects, more commonly termed main effects or indirectly as confounding effects. For instance, and where causality is ordered, a relationship of variable ***A***, say, to child mortality captured by a statistical model declines when another variable ***B*** is subsequently introduced in the model. This decline can be interpreted as the effect of the variable ***A*** operating indirectly through variable ***B***. Thus, changes in the two variables ***A*** and ***B*** are interrelated and such an interaction can contribute to a fuller interpretation of the associations of the independent variables (***A*** and ***B*** in this case) with child mortality.

There are two issues involved in designing a clear framework for the analysis of child mortality. Firstly, the issue related to defining the event of interest and potential correlates (which could be termed a conceptual issue), and, secondly, the issue of correctly choosing an appropriate methodology for analysing factors affecting the occurrence / non-occurrence of that event (which could be termed a methodological issue).

- **Conceptual Issues**

For any given age of interest mentioned earlier, an *index* child, or any child entered in the live births history, is observed to be in either one of two states - alive or dead. A typical problem is which dependent variable to use, the dichotomization of the dependent variable could be both arbitrary and wasteful of information. Allison (1982) discusses how one can avoid these difficulties; he begins with the first suggestion of using of the length of the time from zero to that of the occurrence of an event as the dependent variable in a multiple regression. He argues that the value of the dependent variable would be unknown or censored for persons who experienced no events during the period of follow-up. Next, he discusses an *ad hoc* solution that would exclude all censored observations and just look at those cases for whom the event was observed- a trend followed by earlier WFS studies, which is unbiased but perhaps inefficient. He adds that when the number censored cases may be large, it has been shown that their exclusion will lead to large biases (Sorensen, 1977).

Allison (1982) further presents an alternative ad hoc approach, which is to assign the maximum length of time observed, in this case "length of period of follow-up", say sixty months if where are dealing with survival to age five years, as the value of the dependent variable for the censored cases. This strategy will underestimate the true, and again substantial biases may result (Tuma and Hannan, 1979).

Virtually all models used in the analysis of mortality assume that censoring is independent of the occurrence of the event- that is, individuals are not selectively withdrawn from the sample because they are more or less likely to experience an event. This is entirely plausible, when the censoring mechanism is the time of interview, as in sample survey data.

Another problem with censoring is selectivity, where by children of censored experiences tend to be systematically different from children of the rest of the population under study. One methodology employed in WFS studies was to use controls or stratification on the variables which are believed to manifest the selectivity. Some epidemiological and longitudinal studies have an extra utility of matched case-control studies which when stratifying by the selectivity effect produce purer estimates.

Hence, censoring of experiences by cross-sectional sample surveys remain irreversible; an effective way of handling censoring was to exclude recent censored and uncensored births born within a retrospective length of time, taken to be equal to the age of mortality of interest. Thus, on examining mortality before age five years, all births occurring within the last sixty months before the survey are excluded to allow for equi-exposure for the remaining births.

The composition of the population of interest is another influence - for instance many defined variables may not apply to the whole population of births- the analysis of first births for instance lacks key definitions of influencing factors such as birth spacing and the survival status of older siblings.

Certain correlates are difficult to model given their inter-relation to the dependent variable- an example of which is the effect of subsequent birth interval. The effect of subsequent outcomes on the index child are problematic since the survival chances of births subsequent to the index child are at least partly determined by the outcomes for the index child (Hobcraft, 1987). That is the death of index child implies a short birth interval which raises the risk of death for the next child with possible further implications for subsequent births.

Some variables may have time-varying effects or time-dependent effects on child survival. It might be a bit tricky to distinguish the difference in effects between time-varying and time-dependent variables. An example of the latter is that associated with the status of breastfeeding. The effect of breast-feeding for a newborn offers, as well as full nourishment, a degree of protection from diseases and remains more hygienic when compared to food supplements. After the first few months of life and maybe well into the second year of life, the protective effect of breast-feeding declines and sometimes prolonged breast-feeding could be detrimental to a toddler depriving him/her from essential nutritional supplements. Thus depending on the interval of life under study the effect of breast-feeding will vary. Time-varying factors are factors that change status during the period of observation. For instance, the occurrence of the subsequent pregnancy has a time-varying effect, given its multiple states of no conception, to conception, to birth, respectively (Hobcraft, 1994).

- **Methodological Issues**

In recent years, scholars placed a lot of effort into identifying new methods that could take account of existing features of the data - given complexities in methodological issues. Goldstein (1995: p.7) states that in studying mortality rates in a population, it is often of great concern to try to understand the factors associated with variations from area to area or community to community and whether those could explain between-community variation.

Another interest is the interaction of the birth or individual characteristics with area or family characteristics-for instance are mortality rates different for female children as compared to male children varied from one community to another. Goldstein (1995: p.3) asserts that firstly, it enables data analysts to obtain statistically efficient estimates of regression coefficients. Secondly, by using the clustering information it provides correct standard errors, confidence intervals and significance tests, and these generally will be more 'conservative' than the traditional ones, which are obtained simply by ignoring the presence of clustering. Thirdly, by allowing the use of covariates measured at any of the levels of a hierarchy, it enables the researcher to explore the extent to which differences in mortality between communities are accountable for by factors such as access to clean water, sanitation , and health services .etc, or possibly in terms of other characteristics of the child (model estimation efficiency versus sufficiency).

Where taking into account of the hierarchical structure is not readily possible, a compensating effect could be to condition the event of interest on other characteristics of children within the same household. A life example has been that addition of the survival of the immediate sibling as a measure of a family's excess risk burden. Cesar, Palloni, and Rafalimanana (1997) assert that models (marginal or conditional) that condition on responses of other members of the clustering level introduce tolerable bias compared to models where nothing is done to address intra-clustering correlation.

The purpose of this chapter is to elicit empirically identified correlates of child mortality together with a selective review of the methodologies evolving therewith.

Sections 3.2 and 3.3 discuss the correlates of child mortality, bio-demographic and socio-economic, and how they operate, respectively. Section 3.4 offers an overview of earlier techniques involving the use of life-tables and aggregate measures and the successor multivariate modelling theory commonly used in demographic research. Section 3.5 offers a schema of the study's methodology and extensions the thesis makes on applications of the existing regression multivariate models. Section 3.6 discusses the conceptual framework to be used by the analytical chapters of the thesis, finishing with a brief discussion of the implications of the selected methodological ideology.

3.2 Bio-Demographic Correlates of Child Survival

In recent years a great body of evidence has become available on the study of childhood mortality across diverse cultures and regions of the world. This section examines the strength and consistency of associations between common bio-demographic variables and child survival. The impact of such variables on the risk of early childhood death is thought to be manifest through both behavioural and biological mechanisms. This section further identifies the highest common set of factors pertinent to the three societies of concern.

3.2.1 Definitions:

The first characterising variable is the gender of the index child. A male baby has, on average, an innate biological disadvantage in survival through the first year of life (Waldron, 1983). In some societies preferential care is allocated to male births, at the expense of their counter-part female births, to sustain a better survival chance for them. Research work in parts of the Indian-sub continent (Das Gupta, 1990; and, Muhuri and Preston, 1991) clearly demonstrated preferential treatment in the shape of more health care and food allocation to boys as compared to girls. A heavier mortality burden for one sex will considerably affect a population's age-structure.

Research has shown that there is a strong relationship between maternal fertility patterns and children's survival risks. Calculated as the difference between the index child current age (=age at the time of the survey; or age at death) and the mother's current age, a mother's age at birth has important health and social ramifications. A number of studies identify excess risk associated with very early (less than 20 years of age) and very late (more than 35-40 years of age) maternal age bearing (Hobcraft, McDonald, and Rutstein, 1985; and, Grummer-Strawn, 1991).

Survival chances have been shown to vary with the birth order or rank of the index child. Cumulative evidence suggests first births and births of very high order carry greater than average mortality risk. The factors that combine to produce this effect in the developing country setting are not well understood, nor does the typical U-shaped curve apply to birth order in all studies and in all settings (Sullivan, Rutstein, and Bicego, 1994; Bicego and Ahmad, 1996).

With the exception of the first birth, for each child (referred to as "the index child" in most studies), the length of the preceding birth is defined or measured as the length of time between the index child birth date and that of the immediately preceding sibling. Usually measured in months, this variable shows a uniform association with childhood survival chances -- the shorter the length of the preceding birth interval the more heightened the risk of death for the index child.

Of similar and more pertinent importance is the survival status of the preceding birth. An early death of a preceding birth would result in a short preceding birth interval for the index child. Hence, controlling for the survival status of the preceding birth serves a dual purpose, acting as a proxy measure of the family mortality environment and refines the effects of birth spacing.

Another covariate defined in a similar prospective rather than retrospective manner is the length of the subsequent birth interval. Though not straightforward, this variable entails excess risk for the index child survival chances independent of the length of the preceding interval. The complexity of interpretations is that of reverse-causality where short subsequent birth intervals entail adverse effects for both the index child and the new pregnancy.

Often excluded from child mortality analysis, biologically multiple births are higher risk births – a factor which may further contributes to the above mentioned sequence of bio-demographic higher risk groups. Working with WFS data from 29 developing countries, Rutstein (1983) calculated country-specific infant and child mortality rates for multiple and singleton births. He suggested that the infant mortality rates for multiple births in a country were largely unrelated to the level of infant mortality for singleton births in that country. Obtaining data for 2750 twins' births born in the 5-years preceding 26 DHS, Guo and Grummer-Strawn (1993) use Clayton's (1978) proposed random-effect bivariate hazard model for survival data, with a Gamma distributed random-effect. They assert that twinning tends to amplify or, at least retain whatever group differentials exist among singleton births.

3.2.2 *How are they operating:*

Starting with the effects of genetic frailty of males, these are expected to diminish after the first year of life. The effect of sex-biased parental care on the risk of female child mortality is inferential, in the sense that these practices have not been linked to mortality at the level of the individual child (Nathanson, 1984). Das Gupta (1990) argues that the clustering of deaths can explained to a vary large extent by the basic abilities and personal characteristics of the mother, as the primary carer, independently of her education, occupation or income. Das Gupta (1990) goes further to suggest a significant sex-difference in mortality is an observation reminiscent of maternal competence in the study region.

Many studies identify excess mortality for first births and for teenage births. Hobcraft (1987), using WFS data, states how both experience an increase of risk of about one-third, compared with second or third birth to mothers aged 25-34 (first births are at especially high risk in the Middle East and North Africa, with a two-thirds, rather than one-third, excess risk). Young maternal age at first births is a consequence of a societal pressure towards early ages of marriage and the absence of practice of any form of contraception before the initiation of child bearing. Very young women's reproductive systems for example, may not be adequately prepared for the stress of a pregnancy, while advanced aging seems to reduce the efficiency of the entire reproductive process (Trussell and Pebley, 1984).

Poor survival experience of first births has been commonly attributed to that fact the younger the mother the greater the chance that she has not reached full physical and reproductive maturity. This, in turn, would lead to increased prenatal risk and more difficult delivery. One mitigating factor in this case is education - young mothers tend to be better educated than older, high parity mothers, and they will be more likely to use modern health services.

The causal mechanisms explaining heightened risk for high order births are not well understood. While older high parity women are at increased risk of complications during and after child birth and for delivery of a genetically impaired child, these higher risk births are also related to adverse social and economic factors that are both the cause and consequence of high fertility. Infants in higher births orders may be at greater risk because of general exhaustion of a woman's reproductive system, whereas a first birth may be riskier because the body in undergoing parturition for the first time (Trussell and Pebley, 1984).

Since the early analysis of the WFS data, many competing mechanisms have been formulated to explain the association of mortality risk with spacing of earlier births (Rutstein, 1984; Hobcraft, McDonald, and Rutstein, 1983; and Cleland and Sathar, 1984). The "Maternal Depletion Syndrome" (Jelliffe, 1966) is often cited as an obvious mechanism causing deleterious effects on infant and early child survival. A mother with repeated pregnancies and especially short birth intervals does not have sufficient time for physical and nutritional recovery, and will be probably experience pregnancy losses and babies with lower birth weight (Hobcraft, McDonald, and Rutstein, 1983; and, DeSweener, 1984). Boerma and Bicego (1992) point to antenatal factors, particularly those involving maternal nutrition / depletion, to explain relationships between short birth intervals and high early childhood mortality. Evidence on this issue is mixed, with all the usual problems of assessing the nutritional status of the mother in a meaningful way (Hobcraft, 1987). Malnourished mothers may also be less successful at breastfeeding their children either because diminished quantity or quality of breast milk or because low birth weight infants have a harder time breastfeeding. Hence, taken together, the two mechanisms suggest that close spacing of two births may result in poorer survival chances for both children (Trussell and Pebley, 1984).

Another theory is that of sibling competition -- older children compete directly with the newborn child in the form of a limited food supply and indirectly through sharing mother's care and attention. To simplify the language, when a birth interval is short, there will be at least two young children in a family; this may cause severe pressure on the mother responsible for their care, and thus result in higher probability of losing a child. According to Pebley and Millman (1986), competition among closely spaced siblings is an important determinant of child health, at least after the first few months of life. This piece of evidence is again interwoven with the mechanism of maternal depletion. Hobcraft (1987) explains that settings where a considerable number of pre-school age children live could be an indicator of maternal depletion resulting in low births weight or poor supply of breast-milk.

It will be difficult to distinguish possible competition effects from the possible maternal depletion syndrome. Cleland and Sathar (1984) found a strong positive relation between the length of the preceding birth interval and child survival controlling for the survivorship of the preceding birth, maternal education, rural-urban residence, sex of the child, maternal age and parity. One possible explanation for this association might be that women breastfeed all children for a similar length of time; those women who lactate for short periods, therefore, would have short inter-birth intervals and also higher infant and child mortality. If so, then the association between interval length and mortality would be spurious (Hobcraft, 1987). Cleland and Sathar (1984) also examined how far survival chances of births of order five and above were affected by the average interval between all earlier births, once controls were introduced for the length of the preceding interval and the survival status of that child. Their conclusions unequivocally demonstrated once the controls concerning the timing and survival status of the most recent birth were introduced there was no support of any additional effect from the average interval.

Short intervals could result from the death of the previous birth. Thus, the previous child's death can be held to 'cause' the short interval, and the next child is at greater risk of death because of the familial context. Also, depending on the age of mother and breast-feeding status of the lost child (and with disruption of breastfeeding a mother becomes more susceptible to fall pregnant soon) a subsequent pregnancy and thus a shorter space of time between births. Psychologically, the loss of a child may promote a desire to "replace" the dead child and hence to shorten the interval to next birth-possibly by raising coital frequency or by foregoing contraceptive protection. Examining subsequent intervals effects, Trussell and Pebley (1984) argue that short ones have negative effects on probabilities of survival principally because of earlier weaning. They concluded that maternal depletion is a more plausible explanation for the relation between child pacing and infant and child mortality since this association is not diluted by the inclusion of information on the survivorship of the previous child.

Another complexity is the prematurity of higher risk births that could result in a shorter gestation period and hence shorter birth intervals. Again, effects of reverse causality are probable -- short intervals between conceptions may themselves heighten the risk of prematurity. Work with Malaysian data, showed that a short birth interval (<15 months) was an important correlate of low birth weight, even when many other variables are controlled for (DaVanzo, Butz, and Habicht, 1983 and, 1984). They concluded that short birth intervals have a strong indirect effect upon child survival through birth weight and a direct main effect even when a very wide range of pertinent controls, including birth weight, is introduced. By a more complicated pathway, the length of the subsequent interval affects mortality. To conclusively define the effect of this variable the breastfeeding status of the index child needs to available as well as maybe the date to next-conception. Using WFS data to study this topic is hindered by two problems, a selection bias (breastfeeding information is only available for the last two births) and heaping on certain digits given duration, commonly multiples of 6 (Hobcraft, 1987). Within the first 4-8 months of life, the effects of breast-feeding on health are more pronounced in fully-breast-fed infants (since they are receiving increased amounts of anti-microbial factors and have limited exposure to pathogens). This implies that partial breast-feeding is the optimal type of infant feeding for older infants, since the lower and upper bounds of the protective effects of full breast-feeding are noted at 4-8 and 8-12 months, respectively (Kuate Defo, 1997).

Leading on from the argument of controlling for confounding factors, children are clustered in families, which experience a common environment. Mothers are likely to adopt similar child-care practices for most of their children, although some learning and education may bring more parental competence with increasing parity. At another level, closely spaced children may also cross-infect each other given short outbreaks of infectious diseases such as respiratory infections, for example, measles. If *overcrowding* is considered in its own right, Aaby's (1988) work in Africa showed that nutritional status is lower and the incidence of measles is higher in large families than in small families. A principal cause of higher case-fatality ratios among multiple measles cases in the same household seems to be the higher mortality among secondary cases infected after intensive exposure at home than among index cases infected outside the home (under age three). Aaby (1988) asserts that no study has examined the role of spacing specifically in relation to measles mortality, but it is to be expected that short spacing increases the risk of siblings being infected simultaneously rather than in different years. This principle will further extend to morbidity with other infectious and communicable diseases such as malaria, typhoid and tuberculosis.

Another question of interest almost universal to many studies of childhood mortality is the high significance of the survival status of the immediately older sibling as well as the length of the preceding birth interval. How can the effect of short birth interval be distinguished if the previous child is dead? Zenger's (1993) work shows strong evidence that little or no excess mortality risk is associated with a short preceding birth interval if the preceding child died, but that some excess risk is present if the preceding child survived (Zenger, 1993). She argues that maternal depletion effects should be weaker if the preceding child died (physiological demands if breast-feeding are removed by the death of a child). Also she argues that competition over food and parental care is less, and, transmission of disease between closely spaced children (Aaby et al., 1984) would require the elder siblings must be alive if either sibling competition or increased disease transmission is to occur. She summarises that both of these hypotheses predict no effect of short birth interval on mortality if the preceding child died.

But it can be argued that such short birth intervals should be less common when a previous child has survived; a mechanism of traditional practices of breast-feeding and postpartum abstinence prolonging periods between successive conceptions. Also, Zenger (1993) was investigating neonatal mortality, perhaps not allowing for the pathways of influence (such as maternal depletion syndrome and siblings competition) outlined above to take full manifestation.

Net of the effect of the length of the preceding birth interval, the survival status of the preceding child remains highly significant. As a distinctive correlate and in a methodological context, the survival of the previous child will later prove to a be a valuable addition to correcting for familial factors that are not readily measurable.

Indeed, a number of studies have shown that quite often, mothers in many developing countries modify their breast-feeding and birth spacing behaviour in response to the health and nutritional status of the child (Hull and Simpson, 1985; and, Winikoff, 1982). Maternal illness is also an important factor in a woman's decision to breast-feed (Winikoff, Durongdej, and Cerf, 1988) and has been shown to affect her reproductive function (Gray, 1983; Belsey, 1976; and, McFalls and McFalls, 1984), but has generally been ignored in the discussion of the relationships between breastfeeding, birth spacing and infant and child mortality (Kuate Defo, 1997).

Cantrelle and Leridon's (1971) study of Niakhar district in Senegal revealed that excess mortality just after weaning was shown to be considerably greater if the child was weaned during a subsequent pregnancy, and the effect was larger when this occurred at younger ages. Such a subsequent pregnancy induces early weaning with devastating consequences for the earlier child. Wolfers and Scrimshaw (1975) in a study on Ecuador, showed that an extremely short interval to the next pregnancy raised the risk of death of the earlier child in infancy, but not between ages one and five.

Palloni and Millman (1986) have shown that the effect of subsequent birth spacing attenuates slightly but remain significant even when controlling for the effect of breastfeeding. Hobcraft (1987) encourages replicating Palloni and Millman's (1986) study for regions of the world where breastfeeding is prolonged (e.g. 2 -3 years), where it will be in such circumstances that premature or rapid weaning may have severest consequences.

The reverse causality has also been demonstrated by a few studies. Using data from phases 1 and 2 of the DHS, Grummer-Strawn, Stupp, and Mei (1998) investigated the extent to which the death of a child during early infancy tends to shorten the time until the birth of the next child. It was estimated that the median birth interval is longer when a child lives than when it dies in early infancy. Almost two-thirds of the excess risk associated with an early infant death upon shortening the subsequent birth interval is explained by the premature cessation of breast-feeding. Grummer-Strawn, Stupp, and Mei (1998) further demonstrate that a child's death also had a major effect upon the duration of postpartum abstinence, independent of breast-feeding practice. They concluded that the effect of a child's death continues to operate even after menses and sexual relations have resumed. Part of the effect operates through the truncation of breastfeeding when the child dies. Breastfeeding does seem to confer a protective effect against closing the birth interval, even after return of menses and sexual relations. It also explains most of the effect of the death of the index child has on the susceptible period in Africa- this is not surprising since contraceptive use is generally low in Africa (Grummer-Strawn, Stupp, and Mei, 1998).

3.3 Socio-economic Correlates of Child Survival

Many of the determinants of child mortality are attributes of the family or environment in which the child lives – commonly measured correlates are region of residence, levels of household income, adult literacy, health practices among family members, sanitary facilities, clean water supply and waste disposal facilities. Other determinants could be the properties of the "community" around households, organisation of health care system, ecological characteristics such as climate rainfall, presence of disease vectors, and distribution of land and resources.

3.3.1 *Definitions:*

In the analysis of child survival, "type of place" or "area of residence" refers to the de facto location (urban or rural) of the place where the mother's interview was conducted, and is based on the official classification system of the country (usually the most recent census designation). In some cases, the lack of migration history data prevents the classification of births and deaths according to the actual place of occurrence or enumeration. In many studies where detailed information on these factors was not available, "region-of-residence" has acted as a proxy for such determinants.

The positive impact of parental education and literacy on child survival is well documented (Ware, 1984; Hobcraft, 1993). Measured as "completed years of schooling" or "highest level of schooling reached", parental levels of schooling are key socio-economic correlates of studies of child survival. Relatedly, questions about exposure to media (e.g. reading newspapers, magazines, listening to radio, watching TV) are also collected to shed light on the degree of information, education and communication (IEC) local populations have. Whist the behavioural mechanisms that drive the education-child survival relationship are not completely understood, it is generally recognised that improved or increased use of preventive and curative health technologies by more educated mothers is part of the explanation.

A father is the head of the family and the income earner in many societies of the developing countries. Having higher income occupations e.g. professional employment, may bring certain benefits to the mother and child that are not associated with other types of employment and could influence decisions regarding use of health services. Agricultural occupations are often associated with low levels of disposable income and more basic if not poor household living conditions.

It is important to remember that most of socio-economic and environmental factors are usually measured at the time of the survey and may not fully reflect retrospective conditions pertinent to events of births and deaths.

3.3.2 *How are these factors operating:*

In comparison to rural areas, urban areas are usually associated with better infrastructure, modernisation and in many cases more access to clean water, sanitation and health services. In broad terms, urban residence promotes children's survival chances.

Households with more education enjoy better health, both for adults and for children--a strikingly consistent result of a great number of studies, despite differences in research methods, time periods and population samples. A number of hypotheses have been advanced to explain the relationship between maternal education and child mortality. This association usually survived controls for a number of other socio-economic variables, including the husband's education and occupation (Hobcraft, 1993). From the start, the advantages that a mother's schooling confers on her children's health are felt even before birth. In developing countries better-educated women marry and start their families later, diminishing the risk to child health associated with early pregnancies.

Educated women may easily relate to the importance their own health and how their efficiency has an important bearing on the health of others in the family, particularly children. Education acts as a solvent of higher risk behaviour, for example, in averting teenage and late pregnancies. Hobcraft (1994) summarises the excess risk for first-born children to teenage mothers as being about 40 per cent when averaged over 25 DHS countries. Averting higher risk pregnancies reflects on lower rates of maternal mortality, both on a per birth basis and as a result of having fewer children (Hobcraft, 1994). Cleland (1990) relates this behaviour to a closer social identification with the modern world.

Caldwell's pioneering research work in rural India (1979-84) identified three quantifiable differences by education of mother that were significant in their magnitude and each likely to result in greater survival chances of the children of more educated mothers: i) educated mothers were more likely to take children to the health centre for both preventive and curative medicine; ii) the more educated these mothers are the longer the time they spent with the doctors; and, iii) if it happens that the treatment fails to improve the child's health the educated are much more likely to report this back to the clinic whilst uneducated mothers will anticipate failure and conclude they are to blame for failure of treatment.

Most of the demographic evidence points to a consistent and pervasive monotonic decline in infant and child mortality associated with increasing education of mothers (Kaufmann and Cleland, 1994). One of the significant features of this relationship is the fact that it appears to hold across cultures. Studies by Mensch, Lentzner, and Preston 1985) and Hobcraft, McDonald, and Rutstein (1984) suggested that there is no threshold level of maternal education needed before advantages in child survival begin to accrue; even a small amount of education was usually associated with improved chances of child survival.

Boerma and Bicego (1992) were able to show that a child's health status and use of maternal and child health services are closely linked to educational status of the mother and that the association is only partly explained by the economic standing of the household. The magnitude of association of maternal education and mortality varies with the age of the child, with the strongest effects occurring after infancy - a finding consistent with many previous findings. Wide variation in the strength of this relationship was found across countries – the beneficial effect was found to be less pronounced in sub-Saharan countries and more pronounced in the other regions (Boerma and Bicego, 1992). When both parents are literate the effect of benefit is more than double that when only one parent is literate. When only one parent is literate, mother's literacy appears to have greater impact than father's literacy during the ages 1-4 years (Boerma and Bicego, 1992).

But does this mean that education therefore has some universal features that affect all individuals in the same way, at the same time. The complexity of the pathway thus emerges. Data from the DHS suggest that education does not necessarily make mothers better hygienists (Cleland, 1990; Boerma, Sommerfelt, and Rutstein, 1991).

Yet, is it a matter of access versus action? -- Jain (1994) using an analytical framework asserts how maternal education increases the use of health services for preventive medical care but questioned the effect on their use for curative medical care in the absence of health services. The effect of seeking curative care cannot be ascertained without actually considering the availability of these services at the community level.

A final issue is the role that education plays through the empowerment of women. Cleland (1990) identifies three components to this empowerment, which he terms instrumentality, social identification and confidence. Instrumentality is the ability to manipulate and feel control over the outside world. Social identification is concerned with engagement with modern institutions and bureaucracies. Greater confidence permits the interaction with such officials and bureaucracies. Caldwell (1986) clarifies, within the context of empowerment of women, female education is not the same as female autonomy - although the former may contribute to the latter.

Quantifying the wealth of a household using a list of its belongings (e.g. flooring, type of dwelling, access to electricity, number of electrical items and goods) has done little to describe the household economic status. Using father's income or type of occupation to explain differentials in child mortality has done little to explain variations in mortality levels across households – an inherent problem is in interpreting occupation data using a single set of definitions (Hobcraft, McDonald, and Rutstein, 1984).

In summary, a range of variables and their dynamics have been reviewed illustrating the empirical evidence on the determinants of child survival. The following section discusses families of statistical techniques used in recent decades to analyse mortality, to justify the methodology deployed by this thesis.

3.4 Methods of Analysis of Child Survival

Methods of analysis of child mortality continued to develop with the availability of more detailed and better quality data. The process of sophistication of techniques of analysis was being coupled by the big leaps in computer technology and software design. The following sub-sections are a selective review to reflect the steps of change in applied methods of empirical research in child survival.

3.4.1 Aggregated Data Methods:

At earlier stages of demographic, data structure and availability steered method applicability-one common analytical methodology applied in country case studies and comparative studies was developed by Trussell and Preston (1982). For each woman, an expected proportion dead among her children ever-born is assigned on the basis of her age. The expected proportion is based on the relationships between proportions dead at ages x, say, and q(x)- the probability of dying before age x using a pre-established mortality schedule (Brass, 1967). For each woman, the ratio of the proportion dead among children ever born to the expected proportion dead is formed. This ratio is then used as the dependent variable in an ordinary least squares regression analysis of the form :

$$\frac{PD_i}{E(PD_i)} = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_n X_{ni} + \varepsilon_i \text{..................}(3.4.1.1)$$

where

PD_i = proportion dead for woman i,

$E(PD_i)$ = expected proportion dead for woman i,

X_{1i} , X_{2i} , .., X_{ni} = the values of variables 1,2,..,n for woman i.

Model 3.4.1.1 is a multiple regression model; taking one quantity, β_1 estimates the proportionate effect of a unit increment in the explanatory variable X_1 on child mortality (or for a dummy variable, the proportionate effect of membership in a category relative to being in the reference category). Despite its aggregate nature and in some cases simplification of its explanatory framework, the regression model using this indicator makes it possible to derive estimates of the effect of socio-economic factors on child mortality that are comparable to those obtained when more detailed information on each birth and death is available and more refined statistical techniques are used (Trussell and Preston, 1982).

Paterson and Goldstein (1991) comment that there can be two drawbacks to using aggregate data methods, one technical and the other substantive. The technical one is that statistical estimates can be very unreliable in the sense that slight perturbations to the data or to the model can produce markedly different results. This shows up as large standard errors for estimates, and as high collinearity among predictors. Another reason for the lack of statistical robustness is a problem that aggregate data are remote from the social and behavioural processes that are of interest – it is so removed from causal processes that it provides no help to explanation; disaggregated data are more revealing (Paterson and Goldstein, 1991).

3.4.2 *Life-tables and Child Survival*

One of the mostly commonly used methods in demographic research is the life-table method (United Nations, 1979, and, Brass, 1978). Considered as an indirect method, a life-table offered the possibility of estimating levels and trends in fertility and childhood and adult mortality from responses to simple retrospective questions included in a single census or survey. Those were a reasonable way to list the survival time (or current ages for surviving children and ages at death for dead children) of the live births entries, more effectively when survival is censored by the time of the survey.

The traditional life table is a way of summarising age-specific death rates in a way that is independent of the age structure of the population, usually through statistics such as the expectation of life or the probability of survival from one particular birthday to another. The lay-out of the life-table usually starts by a column describing selected values of age x. The second column may show l_x, the number of children out of an arbitrary 1000 born alive who would survive to their x^{th} birthday

(Armitage and Berry, 1994, p470). A third column gives q_x , the probability that a child, alive at age x exactly, will die before his next birthday. Commonly, q_x is estimated over an interval, expressed as ${}_nq_x$ as the probability of death / failure during the age interval x to $x+n$. Hence, the estimated number of children surviving to age x months is:

$$l_x = l_o p_0 p_1 \ldots p_{j-1} \;, \qquad p_x = 1 - q_x \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.4.2.1)$$

where

q_x = the probability that a child alive at age x years exactly, will **die before** his next birthday;

p_x = the probability that a child alive at age x years exactly, will **survive to** his next birthday.

Life-tables allow time to be divided into intervals depending on the nature of the data (Armitage and Berry, 1994, p.476-477). For example in the study of child mortality, measuring the time of death may be aggregated into intervals as, 0, 1-11, 12-23 and 12-59 months which relate to neonatal, postneonatal, toddler and child mortality intervals of death, respectively. If τ_i is the individual failure or censoring times and the data is aggregated into intervals given by t_j, j=1,..., J and $t_{J+1}=\infty$, with each interval containing counts for $t_j \le \tau \le t_{j+1}$ (Stata 6.0, 1999, p.259). Also supposing at time t_j there were d_j deaths and that just before the deaths occurred there were n_j subjects surviving. Then the estimated probability of death at time t_j is

$$q_{t_j} = \frac{d_j}{n_j}$$

The survival at time t, l_t, is estimated by

$$l_t = S_j = \prod_j p_{t_j} = \prod_{k=1}^{j} \frac{n_k - d_k}{n_k} \ldots\ldots.(3.4.2.2)$$

where the product is taken over all time intervals in which a death occurred, up to and including **t** (Kalbfleisch and Prentice, 1980, p.12, p.15). This estimator is termed the ***product-limit*** estimator of the survival function because it is the limiting form of (3.4.2.2) as the time intervals are reduced towards zero. It is also the maximum likelihood estimator. The cumulative failure is also defined as

$G_j = 1 - S_j$

Defining the within-interval failure rate as

$$f_j = \frac{d_j}{n_j}$$

The maximum likelihood estimate of the within interval hazard, or the age-specific death rate is then:

$$\lambda_j = \frac{f_j}{(t_{j+n} - t_j)} \quad \text{with a standard error estimate } s_{\lambda_j} = \frac{\lambda_j}{\sqrt{d_j}}$$

In sum, current life-tables summarise current mortality and may be used as an alternative to methods of standardisation for comparisons between the mortality patterns of different communities.

3.4.3 *Log-linear Models:*

In the past three decades a big leap forward in the development of demographic methodology has taken place with the transition from aggregates to individuals as the units of analysis. Firstly the use of contingency tables led the way. In the simplest model, the event of interest mortality is cross-tabulated with key correlates, for example a 2x2 table of whether a child survives to age five, and, a variable defining whether his mother was literate or not. The relationship gives four possible combinations or cells, and an expected count in each cell is approximated adequately by the products of marginal totals relevant to the cell position. A *Chi-square* statistic is calculated by the summation of squared differences between observed and expected counts divided by expected counts across all cells. This statistic is tested for significance using appropriate Chi-square tables under appropriate degrees of freedom. But, as the number of covariates being examined increases as well as classes or levels within them, tables grew and manipulations grew more cumbersome. Cross-tabulation and life-table analysis whilst of great value, do not permit the determination of the relative contribution of particular explanatory or predictive factors to particular outcomes in a multivariate framework.

Hence there was a need to look elsewhere for a generalised model that would express the relation between the measure of mortality (for age-intervals under study) as a linear combination of terms, which are specific for the interval and also for other characteristics of the child. With the analysis of contingency tables, the formal statement of the model above was replaced by the log of an expected frequency (in the case of log-linear or hazard models) or the log of the odds ratio of a binary dependent variable (in the case of the logistic models).

Another advantage of these methods is in cross-national comparative analyses is that standard variables can be used and comparisons made as to whether significant variables in one country are also found to be important in others. Should particular factors exert an important influence in all countries considered then greater confidence could be felt as regards to the regional importance of the implied explanatory relationships. Alternatively, divergent results encourage close consideration of features of particular countries, which might help to explain the variation, and can lead to suggestions for different interventions programmes appropriate for different countries.

With a multivariate log-linear model there is allowance for the age-specific risk to vary among individuals with different socio-economic or demographic characteristics. If Y_i is response variable, which equals to 1 if child i dies before age 5 years and 0 otherwise. Then Y_i could be considered as a count variable of events in a Poisson or Poisson-like process (McCullagh and Nelder, 1989, p.194; Armitage and Berry, 1994, p.424) with: $E(Y_i) = \mu_i$, $i=1,\ldots,n$

Supposing for each observation Y_i there is a set of explanatory variables $X_1, X_2,..,X_p$, and that μ_i depends on the values of these explanatory variables. But since Y_i is a positive value count (between 0 and ∞) a transformation or link function $g(\mu_i)$ is needed to make the association linear and to unlimit the values to $-\infty$ and ∞. The usual transformation is the logarithmic transformation. Depicted by model (3.4.3.1) below, it is assumed that the risk of death at any age depends only on time and that all other variation between units is incorporated into the linear predictor; yet the components of the linear predictor may also depend on time.

$$g(\mu_i) = ln(\mu_i) = \beta_1 X_{1i} + \beta_2 X_{2i} + .. + \beta_p X_{p_i} .....(3.4.3.1)$$

Where

μ_i ≡ An expect count of whether child i survives to age 5 years.

Log-linear models are particularly used when the dependent variable is the time elapsing between successive events. The method takes into account complications such as right censoring and the presence of time-varying covariates. The literature can be broken down into categories based on two main approaches: discrete time methods and continuous time methods. Since excellent reviews of the various methods (Allison, 1984; and, Trussell and Richards, 1985) exist, what follows is a selective review of the methods used by this thesis. One approach used by this study is the continuous time method that Cox (1972) developed, which will be discussed in greater detail in Section 3.4.5 to follow.

Using the general method of maximum likelihood, the maximum likelihood estimate of βs and the standard error (and hence the 95% C.I.) can be calculated. But the main restriction of this model is the assumption that the death rate is independent of time. In child mortality, the risks are highest in the initial period and slows afterwards – one way to overcome this restriction is to divide the period of follow-up into a number of shorter periods and the assume the hazard is constant within each interval but different between intervals (Holford, 1976). Trussell and Hammerslough (1983) and Hobcraft, McDonald, and Rutstein (1983) work on infant and child mortality are pioneering examples of the application of a piece-wise log-linear models to test the effects of a number of correlates and comparing simpler models with more complicated ones. Hobcraft, McDonald and Rutstein, (1983, 1984, 1985) were able to produce three models which will remain as important landmarks when assessing the correlates of child mortality and played an important role in documenting the health benefits of birth-spacing.

3.4.4 Logistic Models:

The logistic model falls into the broad realm of generalised linear models in which a linear predictor is connected with the expected value of the dependent variable via a so-called link function (McCullagh and Nelder, 1983). In the case of binary dependent variables, the logistic function is the most frequently used link due to its relative ease of interpretation.

Consider the binary variable Y_i which can take only two values, either child i survives to age 5 years (Y_i=1) or he does not (Y_i=0).

We may write

$$pr(Y_i = 0) = 1 - \pi_i; \qquad pr(Y_i = 1) = \pi_i \quad ....(3.4.4.1)$$

where π_i is the probability that child *i* will die before age 5 years. In most investigations, there is a vector of covariates or explanatory variables (X_1, X_2,...,X_p) associated with each individual. The principal objective of a statistical analysis, therefore, is to investigate the relationship between the response probability π_i and the explanatory variables $X_1, X_2, \ldots, X_p$. One may suppose the dependence of π_i on $X_1, X_2, \ldots, X_p$ occurs through the linear combination

$$\eta = \beta_0 + \beta_1 X1_i + \beta_2 X2_i + \ldots + \beta_p Xp_i \ldots\ldots.(3.4.4.2)$$

But one restriction is that $0 \leq \pi_i \leq 1$ and to express π_i as a linear combination (3.4.4.2) would be inconsistent with the laws of probability (McCullagh and Nelder, 1989, p.108). One effective solution is to use a transformation $g(\pi_i)$ that maps the unit interval onto the whole real line $(-\infty, \infty)$. A wide choice of link functions $g(\pi_i)$ is available –one of which is the ***logit*** or logistic function, which can be written as

$$g(\pi_i) = \log\left(\frac{\pi_i}{1-\pi_i}\right) = \eta = \beta_0 + \beta_1 X1_i + \beta_2 X2_i + \ldots + \beta_p Xp_i \ldots\ldots\ldots\ldots\ldots\ldots(3.4.4.3)$$

Hence, the probability of a positive outcome is

$$\pi_i = \frac{\exp(\beta_0 + \beta_1 X1_i + \beta_2 X2_i + \ldots + \beta_p Xp_i)}{1 + \exp(\beta_0 + \beta_1 X1_i + \beta_2 X2_i + \ldots + \beta_p Xp_i)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.4.4.4)$$

Equation (3.4.4.3) is a simple model that describes the ratio between the observed proportion of births dying before age five and the proportion of those who do not as an exponential function of a linear combination of covariates. The ***logit*** is the logarithm of the odds, and logit differences are logarithms of odds ratios, that is the ratio of the odds of death to survival - when this ratio departs from unity it implies excess risk for the relevant groups or class of the covariate. Logistic models can also be considered as discrete-time hazard models - for example when the risk of death in non-proportional in time, piece-wise logistic models can be deployed where the dependent variable is the ***q-function*** of the life table, where $_nq_x$ is defined as the conditional probability of death occurring in the interval x+n given that a child was alive at age x. Given the ease is statistical interpretation, logistic models are quite commonly used in the analysis of child survival with the adaptation of special adjustment of exclusions of recent births to alleviate some of the bias caused by censoring of survival experience.

3.4.5 Cox Hazard Models:

Originated by Cox (1972), demographic applications of these models lagged by several years, despite awareness by many statistically oriented demographers of the great potential of these models. Computer software was either not generally available or difficult to use, the preparation of data for these models was seen as, and in fact was, a formidable task. In order to produce statistically stable estimates, large data sets were needed, with proportionately high costs of data preparation, imputation of missing dates, re-coding, and so on.

Today, these models are widely deployed in demographic studies of child mortality since they obviate the need to exclude recent births given censorship of experience by the survey time. Studies mentioned above (Palloni and Millman, 1986; and, Lantz, Partin, and Palloni, 1992) have shown that Cox model give consistent estimates to those produced by logistic models and the more restricted hazard models. One clear description the Cox model is found Collett (1994), customised below to fit the framework of analysing child survival.

In the case of child mortality, survival data is modelled with Cox's semi-parametric model so termed since no particular form of probability distribution is assumed for the survival times (ages of death in the case of dead children) are made. The hazard of death at a particular time for this model depends on the values x_1, x_2, .., x_p of p explanatory variables X_1, X_2, .., X_p. The values of these variables are usually recorded at the time origin of the study. Thus, if a model starts by allocating certain categories of these explanatory variables as reference groups, then the hazard associated with those is $h_0(t)$, or the baseline hazard. Usually, it remains more convenient to allocate these explanatory variables baseline values to the more advantaged groups, so that the corresponding hazard ratio estimates describe the relative excess hazard associated with disadvantaged groups relevant to such a set of explanatory variables. Whenever the hazard ratio ψ departs from unity, it will either imply excess risk or vice versa. Hence, the hazard function for the i^{th} child can be written as

$$h_i(t) = \psi(x_i)h_0(t)................(3.4.5.1)$$

where $\psi(x_i)$ is a function of values of the vector of explanatory variables for the ith child. The function $\psi()$ can be interpreted as the hazard at time t for a child whose vector of explanatory variables is x_i, relative to the hazard for a child for whom x=0 (Collett 1994, p.56). Since the relative hazard $\psi(x_i)$ cannot be negative, it is convenient to write this as $\exp(\eta_i)$, where η_i is a linear combination of the p explanatory variables in x_i.

$$\eta_i = \beta_0 + \beta_1 X1_i + \beta_2 X2_i + ... + \beta_p Xp_i................(3.4.5.2)$$

The proportional hazard model then becomes

$$h_i(t) = exp(\beta_0 + \beta_1 X1_i + \beta_2 X2_i + ... + \beta_p Xp_i)\, h_0(t) \qquad (3.4.5.3)$$

which can be re-expressed as

$$log\left(\frac{h_i(t)}{h_0(t)}\right) = \beta_0 + \beta_1 X1_i + \beta_2 X2_i + ... + \beta_p Xp_i \qquad (3.4.5.4)$$

Often when an appropriate parametric form $h_0(t)$ is unknown, or is not of primary importance, it would be more convenient if it was unnecessary to substitute any particular form for $h_0(t)$ – an approach introduced by Cox (1972). The model is then non-parametric with respect to time but parametric in terms of the covariates. Equation (3.4.5.3) does not supply absolute measures of risk but does supply the relative risks for each birth, since although $h_i(t)$ is unknown but the same for each birth (Armitage and Berry, 1994, p.485). The model is fitted by the maximum likelihood technically termed partial likelihood.

On many occasions, survival time studies do not yield distinct failure times. The partial likelihood method used to fit the Cox model depends on the rank ordering of events and the resulting tied failure times pose special problems. Several approximations have been proposed for handling ties in proportional hazards regression (Peto, 1972; (Kalbfleisch and Prentice, 1973); Breslow, 1974[3]; Efron, 1977; Oakes, 1981; Farewell and Prentice, 1980; Sinha, Tanner, and Hall, 1994). Assessing the numerical comparison among these commonly used approaches is generally lacking in the literature. Hertz-Picciotto and Rockhill, (1997) undertook a simulation study to investigate the bias, efficiency, standard errors and coverage using Breslow (1974), Efron (1977) and Kalbfleisch and Prentice (1973) approximations. Although their study did not address data with censoring, their results show the Efron approximation for the likelihood under tied failure times in proportional hazards regression performed far better than the other two approximations especially with heavier ties and smaller sample sizes. On average, the Breslow approximation underestimated regression coefficients, while the Kalbfleisch and Prentice approach generally overestimated them (Hertz-Picciotto and Rockhill, 1997).

The full power of the proportional-hazards model comes into play when there are several covariates (Kalbfleisch and Prentice, 1980) and equation (3.4.5.3) represents

[3] Breslow's (1974) method is the default for many survival analysis programmes.

a multiple regression model. Once a suitable model for a set of survival data has been identified, the hazard function, and the corresponding survival function, can be estimated. The estimate can then be used to summarise the survival experience of individuals in the study.

3.4.6 Random-effects / Multilevel Models:

For some time now, and since the analysis of the WFS data, some concern was felt about ignoring the inbuilt hierarchies and the resulting correlation between sibling's survival outcomes. In essence, children within any one household, because they are cared for by the same mother and share the same housing environment, tend to be similar in their experience. As a result, they provide less information than would have been the case if the same number of children were from unique households. In a household survey, the first stage-sampling unit will often be a well-defined geographical unit. From those, which are randomly chosen, further stages of random selection are carried out until the final households are selected. Given the statement of interest, the *hierarchical* structure if often ignored- that is the population structure, insofar as it is mirrored in the sampling design, is seen as a 'nuisance factor'.

By contrast, the multi-level modelling approach views the population structure, as of potential interest in itself, so that a sample designed to reflect that structure is not merely a matter of saving costs as in traditional survey design, but can be used to collect and analyse data about the higher level units in the population (Goldstein, 1995: p.5).

Multilevel modelling can respect the heterogeneity of biosocial experience. It is possible that there are unobservable characteristics that affect the probability of survival. Vaupel, Manton, and Stallard (1979) termed the bundle of unobservable effects frailty (Trussell and Hammerslough, 1983). Recognition that heterogeneity is likely to exist has led several investigators to incorporate it explicitly in their models (Vaupel, Manton, and Stallard, 1979; Manton, Stallard, and Vaupel, 1981).

During the past decade, considerable progress has been made towards the estimation of multilevel models. Several researchers, including Entwisle and Mason (1983), Goldstein (1986), Raudenbush and Bryk (1986), and, Longford (1987), have developed techniques and computer programs for fitting hierarchical linear models that incorporate normally distributed random errors at various levels. Given technical complexities of the estimation procedures for these models, researchers continue to refine tools of multi-level modelling. Many refinements have been added to other tools by Goldstein and Rasbash (1996) and Longford (1997), to improve on the estimation procedures, further highlighted in Chapter Five.

Random-effects logistic models assume that the individual probability of death equals the fixed effects, as above, plus a random perturbation on the logit scale. To introduce adjustment for "intra-level" correlations, a random effect is assigned for each level of clustering. These effects are captured by random variables and assumptions are made about those, for example, they are independent and follow a normal distribution. The random variables have a mean of zero and variance given by the variance component estimate of the model. By estimating a variance component for those random variables, one can test whether they are sizeable and significantly different from zero. When the variance-components are tested against their standard errors and found to be significant then the "true" random effect is sizeable and its 95% C.I. shifts away from zero. If the variance component of the frailty distribution is zero (or insignificant), then observations from that level are independent. A larger variance implies greater heterogeneity in frailty across the members of that level and greater correlation among observations belonging to that member. The odds ratios estimated from the random-effects logistic model are level-specific, that is they represent the effect of a particular variable on the odds of death within the particular level, e.g. the particular family.

To give an example, consider a 3-level hierarchical structure with the child at the first level (i^{th} level), the mother or household at the second level (j^{th} level) and the geographical cluster at the third level (k^{th} level), respectively. The transition of model 3.4.6.1 to incorporate the variance structure of the multilevel structure is in using a single variance term at each of the three levels. These terms are assumed not to depend on any of the explanatory variables.

$$pr(Y_{ijk} = 0) = 1 - \pi_{ijk}; \quad pr(Y_{ijk} = 1) = \pi_{ijk} \quad \ldots\ldots\ldots\ldots\ldots\ldots(3.4.6.1)$$

The observed responses Y_{ijk} are proportions with the standard assumption that they are binomially distributed (Goldstein, 1995, p.98). Thus,

$$Y_{ijk} \sim Bin(\pi_{ijk}, n_{ijk})\ldots\ldots\ldots(3.4.6.2)$$

where n_{ijk} is the denominator of the proportion and π_{ijk} is the expected proportion dead before age five. Also,

$$\mathrm{var}(Y_{ijk}\mid \pi_{ijk}) = \frac{\pi_{ijk}(1-\pi_{ijk}).}{n_{ijk}} \quad \text{.........(3.4.6.3)}$$

Expressing Y_{ijk} in the standard way and including the level 1 variation as

$$Y_{ijk} = \pi_{ijk} + e_{ijk}\, Z_{ijk}, \quad Z_{ijk} = \sqrt{\frac{\pi_{ijk}(1-\pi_{ijk}).}{n_{ijk}}}, \ \sigma_e^{\ 2} = 1 \quad \text{.........(3.4.6.4)}$$

Using the *logit* link function:

$$logit(\pi_{ijk}) = ln(\frac{\pi_{ijk}}{1-\pi_{ijk}}) = \beta_{jk} + \beta_1 X1_{ijk} + \beta_2 X2_{ijk} + .. + \beta_p Xp_{ijk} \text{......(3.4.6.5)}$$

With the expected probability of death before age five re-written as:

$$\pi_{ijk} = \frac{exp(\beta_{jk} + \beta_1 X1_{ijk} + \beta_2 X2_{ijk} + .. + \beta_p Xp_{ijk})}{1 + exp(\beta_{jk} + \beta_1 X1_{ijk} + \beta_2 X2_{ijk} + .. + \beta_p Xp_{ijk})} \text{..........(3.4.6.6)}$$

The expression $\beta_{jk} + \beta_1\, X1_{ijk} + \beta_2\, X2_{ijk} + .. + \beta_p\, Xp_{ijk}$ is known as the fixed part of the model. In the equation (3.4.6.4) e_{ijk} is the error term on the probability scale of the departure of the i[th] child actual value of his/her logit(π_{ijk}) from that predicted by the fixed part of the model. Using the explanatory variable Z_{ijk}, and constraining the level 1 variance with this to be one, one obtains the required binomial variance in equation (3.4.6.4) (Goldstein, 1995, p.98). Basically, in the multilevel case of several clusters, which are regarded as a random sample of clusters from a population of clusters (the same for households within these clusters), one can assume a regression relation for each household within each cluster with parallel slopes. So β_{jk} can be re-expressed as

$$\beta_{jk} = \beta_0 + V_k + U_{jk} \text{........}(3.4.6.7)$$

hence replacing the value of β_{jk} in the model above,

$$logit(\pi_{ijk}) = ln(\frac{\pi_{ijk}}{1-\pi_{ijk}}) = \beta_0 + \beta_1 X1_{ijk} + \beta_2 X2_{ijk} + .. + \beta_p Xp_{ijk} + V_k + U_{jk} \text{........(3.4.6.8)}$$

Where β_0 , with no subscripts is a constant, and, V_k is the departure of the k[th] cluster's intercept from the overall value, a level-3 residual, which is the same for all households in the k[th] cluster. U_{jk} is the departure of jk[th] household's intercept from the overall value, a level-2 residual that is the same for all children in the jk[th] household. In general, wherever an item has three subscripts $_{ijk}$, it varies from child to child within a household, and from household to household within clusters. Where an item has a jk subscript only it varies across households but has the same value for all the children within a household, and, an item with only a k subscript will vary between clusters but remain constant for all households (and hence all children within those households). In equation (3.4.6.8), both V_k , U_{jk} are random quantities, whose means are assumed to equal zero; they form the random part of the model. The standard assumption is that at different levels random variables are un-correlated and that they follow a normal distribution so that it is sufficient to estimate their variances σ^2_v and σ^2_u , respectively.

Succinctly, empirical demographic research benefited from the application of random variance-component model (Curtis, Diamond, and McDonald, 1993; Guo, 1993; Curtis and Steele, 1996; Amin, Diamond, and Steele, 1997; Pebley, Goldman, and Rodriguez, 1996; Sastry, 1996, 1997), and researchers remain very enthusiastic about recent findings in the analysis of contextual or community variables and their relation to childhood mortality.

Aside from the fact that random-effect models produce estimates that are family-specific, they assume that all siblings correlate equally given their survival experience; this might not be a valid assumption given that siblings of a closer parity as well as short birth intervals are likely to have stronger correlation as compared to older versus younger siblings spaced further apart. This paves the way for discussion of another family of models.

3.4.7 Generalized Estimating Equations (GEE):

Demographic research gave a big reception to new methodology that emphasised "intra-familial" correlation affecting childhood mortality. Another approach, which parallels the random-component models mentioned in the previous section, is that of the Generalised Estimating Equations (GEE) introduced by Liang and Zeger (1986). The principal difference is that GEE obtains the estimate of the variance components using simple regression or "moment" procedures based upon functions of the actual calculated raw residuals. It is concerned principally with modelling the fixed coefficients rather than exploring the structure of the random component of the model (Goldstein 1995, p.23).

Zenger's (1993, p.480) work on analysing neonatal mortality is a key example of these methods; which compared three models; a marginal model as a conventional logistic model; a transitional model as a marginal model with survival outcome of the earlier siblings as explanatory variables in the model (to allow the association of siblings' risks to depend on the lag or difference in birth orders between pairs of siblings); and a random-intercept logistic model which controls for a family / household effect.

The model below describes the logit of the marginal probability of death, $E(Y_{ij})$, a linear function of explanatory variables, X_{ij}. The marginal probability is the expected probability of a neonatal death at a particular combination of levels of the explanatory variables.

$$\text{logit}\left[(E(Y_{ij})\right] = X_{ij}^{'}\beta .....(3.4.7.1)$$

where X'_{ij} is matrix of p explanatory variables and β is a matrix of p+1 coefficients. Closely related to quasi-likelihood methods, GEE provides consistent estimates of regression coefficients and their standard errors without specifying the full joint distribution of the subject's observations. The marginal approach avoids the problem of mis-specification because no assumptions are made about the distribution of the correlation between observations. Transition models allow the association of siblings' risks to depend on the lag (the difference in birth orders) between pairs of siblings. The number of previous outcomes determining the transition probability is called the order of the model. For example, a first-order transitional model, assumes that the index child's mortality is independent of earlier siblings mortality, given the survival status of the immediately elder child, which looks like this:

$$logit\left[(E(Y_{ij} \mid Y_{ij-1})\right] = X_{ij}^{'}\beta^{*} + Y_{ij-1}Y_{ij}\gamma ....(3.4.7.2)$$

Model (3.4.7.2) is a first-order transitional model describing the logit of the probability of neonatal death conditional on the immediately elder-child's survival status as a linear function of explanatory variables. GEE can be used to obtain consistent estimates of transitional models even when the Markov assumption does not hold (Ware, Lipsitz, and Speizer, 1988).

Pair-wise odds ratios obtained from the transitional model showed that association of siblings' mortality risks *depends* on the lag between pairs of births. Zenger (1993) concluded that the stronger association observed for immediate pairs of siblings may indicate that familial mortality effects change over time or with maternal age, so that conditions experienced by siblings close in age (smaller lags) are more similar than those for siblings born farther apart.

3.5 The Study's Methodology and Innovation:

The data used for all analytical work in this thesis is a sub-set of retrospective maternity histories collected for eligible women in the PAP-CHILD sample surveys. Eligible women at the time of the survey were those aged 15-54, currently or previously in a marital union. In Chapter Four a full description will be provided of the respective data sets. To start with, descriptive analysis using life-table methods are used to establish bivariate relations between childhood mortality and explanatory variables (bio-demographic and socio-economic). Second to use is an exploratory analysis of child survival (as survival to age 5 years) and the marginal logistic regression model mentioned in Section 3.4.4. Since the analysis handles survey data, generally, three important characteristics are expected: sampling weights – also called probability weights, clustering and stratification. Including the sampling weights in the analysis gives estimators that are approximately unbiased; weights will also affect the estimation of standard errors for these estimates. In the case of Yemen, sampling weights have to be used given that the household sample was not self-weighting. In these surveys mothers are not sampled independently, that is to say a group of households, hence women, are sampled as a "cluster". For these data sets, "clusters" are the primary sampling units (PSU) consisting roughly of a group of about thirty households. Accounting for clustering is necessary for "honest" estimates of standard errors and hence, valid p-values, and confidence intervals whose true coverage is close to 95%.

Furthermore, in surveys, different groups of clusters are often sampled separately. These groups are called strata. Commonly, strata are broad geographical regions or governates, where sampling is done proportional to percentages of urban and rural clusters within governates. Thus, strata are statistically independent and can be analysed as such. In many cases, this produces smaller estimates of standard errors. It is hence important to use sampling weights in order to get the point estimates right. Considering the clustering and stratification of the survey design gets the standard errors right. ***Svy-commands*** in STATA© provide variance estimators suitable for use with multistage sample data described above[4]. The *svy-logistic* estimators are based on maximum-likelihood estimators.

The first innovative calculation of this study is in the set of "familial-mortality" indicator variables. Two of these indicators are time-invariant and two are time-varying. Time-invariants are the indicator variable of the survival status of the immediately preceding birth, and a complex interaction term of counts of older siblings deaths (prior to the birth of each index child) and the birth order of the index child. The process of creating the latter indicator involves a single-run programme with recursive counters to deposit the number of older siblings dead prior to the birth of each index child.

The first of the time-varying variables is an indicator of a "new" death of an older siblings alive at the time of birth of the index child. To indicate the correlation to a subsequent birth, the second time-varying variable distinguishes the status of subsequent pregnancy (a conception, a birth and in some cases, a death). Thus, the first five-years exposure for each child was broken into a sequence of discrete time units or records to depict the changing status of the time-varying variable. Each discrete time unit for each child is treated as a separate observation or 'episode'. For each of these observations, the dependent variable is coded 0 whilst the index child is alive and changing to value 1 if the index child dies before age five. Figure 3.5.1 below shows a hypothetical example of the time-varying states of the explanatory variables for two index children, ***A*** and **B**. For child ***A***, at age fifteen months, his mother would have conceived his subsequent sibling, so the a new "episode" is created between the discrete value months fifteen and sixteen to capture the change of "Status of subsequent birth" from value 0 to value 1 to indicate change of status from no conception to conception, respectively. The index child will hence keep the new value of his / her time varying covariates until death aged twenty months.

For index child ***B***, one older sibling (older than the immediately previous sibling) died when index child ***B*** reached age ten months. On reaching age 15 months, a subsequent conception takes place, that was born when child ***B*** reached age twenty four months. The latter subsequent birth survived for four months only and died when the index child ***B*** reached age twenty-eight months. Index child ***B*** then

[4] For a detailed discussion of the advantages of using svy commands refer to Chapter 30, Overview of survey estimation (p.320-333) STATA© 6.0 User's Guide, STATA Corp, 1999.

survives post age five years, during which time he experienced one extra older sibling death and one subsequent pregnancy's conception, birth and death, consecutively.

Fig. 3.5.1: A Hypothetical example of the change in status of the time-varying-covariates

	t_0	t_1	Count of older sibling deaths	Status of subsequent birth 0=no conception 1=conception 2=birth 3=death	Index Child survival status 0=alive 1=dead
Child: ***A***	0	15	0	0	0
	15	16	0	1	0
	16	20	0	1	1
Child: ***B***	0	9	0	0	0
	9	10	1	0	0
	10	15	1	1	0
	15	24	1	3	0
	24	28	1	4	0
	24	60	1	4	0

Another perspective deals with the Cox model hazard ratios, which are approximate measures of relative risk. The odds ratio (OR) is equivalent to the relative risks (RR) only when the frequency of the outcome is 10 per cent or less, this approximation breaks down if the "rare event assumption" is invalid (Hogue, Gaylor, and Schulz, 1983). In this case, the relative odds will overstate the relative risk to different degrees when the outcome is common (Gray, 1990). It is however possible to estimate comparative relative risks from odds ratios. Hogue, Gaylor, and Schulz (1983) have shown that even with frequent outcomes the relative risk can be estimated from odds ratio if auxiliary information is available on the overall probability of the outcome or the proportion of exposure (to the outcome) in the population. To allow for a better comparison of the Cox model results to those of the survey-design adjusted logistic regression, the formula will be employed transferring the odds ratios obtained from the survey logistic to relative risks (OR*) (Hogue, Gaylor, and Schulz, 1983; Gray, 1990; Boerma and Bicego, 1992).

$$OR^* = \frac{OR}{(1 - Pref) + (OR \times Pref)} \text{........} (3.5.1)$$

Where:

OR = Odds Ratios resulting from the survey-design adjusted logistic model;

OR^* = The transformed OR to RR;

$Pref$ = The prevalence of the outcome considered in the reference group(s) in the multivariate relation.

Hogue, Gaylor, and Schulz (1983) assert that the adjustment remains viable regardless of the level of *Pref.*

Another motivation comes from the work by Trussell and Pebley (1984) who generated quantitative estimates that show to what degree mortality in these countries would be reduced under hypothetical changes in the distribution of maternal age at birth, birth order, and birth spacing patterns. After providing convincing mortality reductive scenarios, Trussell and Pebley (1984) concluded their effort saying they are unable to estimate the combined effect of changing age, parity and birth spacing simultaneously because there as no studies that report results when all three factors are included in the same multivariate model. The odds ratio (OR) or relative risks (RR) are measures of association between exposure and outcome but do not reflect the public health relevance of an exposure, which is best measured by the risk or excess disease attributable to exposure. The epidemiological measure, population attributable fraction, summarises the percentage reductions in mortality rates if the extra risk factors or groups were averted. Based on the equation development by Greenland and Drescher (1993), attributable fractions are estimated via maximum likelihood estimation from a logistic model (Brady, 1998)[5]. Under the rare disease assumption, the relative risk is approximated by the odds ratio from the ***svylogistic*** model. The generalised equation gives the summary attributable fraction for all the factors combined, that is, the proportion of mortality which is due to all risk effects under consideration.

$$AF = \Pr(\text{risk.effect} / \text{death of a child}) * \left(1 - \frac{1}{RR}\right) \text{........(3.5.2)}$$

In order to estimate the effect of one risk factor while adjusting for other covariates, the RR_j is modified to reflect the additional risk factor of interest contributes to factor category j. Categories in which the risk factor does not appear therefore have RR=1. The RR_j for categories including the risk factor is estimated by the adjusted odds ratio from the logistic regression model. The subscript ***j*** reflects the estimate of the effect of factor j while adjusting for other covariates.

$$AF = \Pr(\text{risk.effect} / \text{death of a child}) * \left(1 - \frac{1}{RR_j}\right) \text{........(3.5.3)}$$

[5] Using STATA aflogit customised to run after estimates of ***svylogistic*** were obtained

Algebraically the population attributable fraction has bounds [-∞, 1] (Brady, 1998). Negative estimates of the attributable fraction correspond to protective effects (RR < 1) where the interpretation is the proportion increase expected in the mortality rate if the protective exposure were absent from the population. Implicit in this measure are very strong assumptions about causality, namely that removing the exposure from the population would reduce mortality (Brady, 1998). Estimating the attributable fraction (AF) from within a logistic regression framework enables confounders to be taken into account and allows estimation of the summary attributable fraction for a set of exposures. This might be of interest to those planning an intervention "package".

The second innovation is with the structure of the variance components of the multilevel-logistic regression model (3.4.6.5) on page 118. The latter can also be expressed as

$$logit(\pi_{ijk}) = ln(\frac{\pi_{ijk}}{1-\pi_{ijk}}) = \beta_{jk} + \beta_1 X1_{ijk} + \beta_2 X2_{ijk} + .. + \beta_p Xp_{ijk} + \sigma_v v_k + \sigma_u u_{jk} ...(3.5.4)$$

Where v_k and u_{jk} have a N (0,1) standard normal distribution and σ_v is a scale parameter that indicates the variation across clusters on the logit scale and is the standard deviation of the normal distribution of V_k . σ_u is a scale parameter that indicates the variation across household or families on the logit scale and is the standard deviation of the normal distribution of U_{jk} .

One extension to this formula is in the estimation of one scale parameter σ_v, which indicates the variation across clusters. Motivated by Sastry's (1997) findings, the variance components can be split with respect to a collective feature for each country e.g. clusters within the same governate or region. For example, if that was to be done at the highest hierarchical level, which is the cluster in this study, there will be more than one slope to describe unmeasured cluster-effects. Returning to original logistic equation formula (3.5.4), the breakdown of β_{jk} will be estimated by:

$$\beta_{jk} = \beta_0 + V1_k + V2_k + .. + Vn_k + U_{jk} ......(3.5.5)$$

Where n corresponds to the number of regional divisions, for example regions are five in the case of Egypt, six in the case of Sudan and two in the case of Yemen, respectively.

The revised model (3.5.4) becomes:

$$logit(\pi_{ijk}) = ln(\frac{\pi_{ijk}}{1-\pi_{ijk}}) = \beta_0 + \beta_1 X1_{ijk} + \beta_2 X2_{ijk} + .. + \beta_p Xp_{ijk} + \sigma_{v1} v_1 + .. + \sigma_{vn} v_k + \sigma_u u_{jk} ...(3.5.6)$$

σ_{v1}, σ_{v2},..., σ_{vn} are the scale parameters that indicate the variation across clusters, within regions 1,..,n, on the logit scale, respectively. Also, these are the standard deviation of the normal distribution of $V1_k$, $V2_k$,..,Vn_k respectively. When any of σ_{v1}, σ_{v2},..., σ_{vn} estimate to zero, it will imply that clusters within their respective region have zero correlations.

Lastly, from the variance-component "intra-cluster" and "intra-household" correlation coefficients can be calculated from the formula given below. The formula treats the error term associated with the i^{th} child of the j^{th} mother / household in the k^{th} cluster as having a standard logistic distribution with mean 0 and variance $\pi^2/3$. (Johnson and Kotz , 1970; and, Pebley, Goldman, and Rodriguez, 1996).

For the "intra-cluster" correlation;

$$\rho_v = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_u^2 + \pi^2/3} ....(3.5.7)$$

For the "intra-household" correlation;

$$\rho_u = \frac{\sigma_v^2 + \sigma_u^2}{\sigma_v^2 + \sigma_u^2 + \pi^2/3} ....(3.5.8)$$

Only positive correlations can be represented in this model (Pebley, Goldman, and Rodriguez, 1996). Both values will lie between zero and 1 – when the estimate of the "intra-household" correlation is high, it will indicate that household-family environments are more heterogeneous than expected if clustering was ignored and hence a child's survival chance are affected by household-specific unmeasured factors. Otherwise, if the variance-components estimates behind these correlations are small and insignificant then a child's particular membership in any one household (in any one cluster) should have little if no effect on his/her survival chances. Interest is in the changes to these estimates induced by adding on more explanatory variables.

The statistical implications of the variance-components estimates will be further assessed vis-à-vis predicted probabilities for survival from a suitable predictive multi-level model (Pebley, Goldman, and Rodriguez, 1996; Curtis, Diamond, and McDonald, 1993; and, Curtis and Steele, 1996). Three levels of the cluster and household random effects V_k and U_{jk} will be employed which respectively denote two standard deviations below average, average and two standard deviations above the average cluster or household unmeasured effects.

To summarise, the study's units of measurements are child records obtained from the PAP-CHILD surveys retrospective maternity histories. To maintain comparability across countries the set of predictor variables is kept the same, which include:

The bio-demographic covariates which are the maternal age at birth, sex, length of the preceding birth interval, survival status of the preceding birth and an interaction term of birth order with counts of older siblings mortality prior to the birth of the index child. The new additions are the time-varying covariates of extra older siblings death and the survival status of the subsequent pregnancy.

The socio-economic indicators which are the literacy of mothers, the literacy of husbands, the type of area of residence, and whether husbands' occupation was in agriculture.

For the cluster-level, extraction of pertinent factors is not straightforward. This is because sample surveys tend to measure characteristics of the community or cluster indicative of conditions close to the time of the survey. Previous work with community-survey data has shown insignificant explanatory power when added to models investigating child survival (Casterline 1983. In his conclusions, Casterline (1983, 1987) recommended making use of community-effects estimated by aggregating information on the individual survey or / and household survey, known as *contextual effects.* One argument is that many economic factors typically operate at high-levels of aggregation, although their effects maybe conditioned by local factors. One effort has been to start-off with relaxed assumptions that given the rate of development has been moderate in the period selected, and to "collapse" multiple characteristics gathered at the household level to obtain aggregated "contextual" measures of the higher cluster-level (Gould, 1995). The cluster "contextual" indicators describe the clusters' type of sanitation, the source of water supply and access to electricity, respectively.

Many of the variables concerned with the timing and clustering of births, such as previous birth interval, survival of the previous child, deaths of any older siblings, deaths of siblings older than the prior birth will not apply to first births. For that reason, the analyses to follow in Chapters four and five will be segregated for first and higher order births. Fitting of the survey logistic and Cox model will be carried out the statistical software package STATA© (Stata 6.0, 1999) and the multilevel logistic model using the multi-level statistical software MLwiN© (MLwiN, 1998), respectively.

3.6 Summary and Implications:

In this chapter, a selective review was presented of concepts of child mortality and the associated methodologies, summarising inter-related findings in the past three decades. The thesis will examine three societies of the Middle East and North Africa, which are characterised by low incomes, yet larger family sizes, despite considerable child losses and pregnancy wastage through a couple's reproductive life.

Households, to some extent, are still characterised by overcrowding; this is presumably connected with many adverse health factors, such as poor nutrition, traditional treatment, non-utilisation of health services, poor hygiene, high risk of complications, and high frequency of previous and underlying diseases in the household. Measures of the "clustering" of mortality within a household (or as children belong to the same mother) would hence as proxy measures of the breeding environment.

In an extra bid to understand more about the risk of mortality within a family setting, the analyses will apply multi-level modelling techniques to account for the hierarchical structure of the data. This process is guided by two different strands in the literature to explain what would be a within-family correlate of mortality and a between-family correlate of mortality.

As Cesar, Palloni, and Rafalimanana (1997) describe it, the first strand was concerned with the within-family correlates where a problem of omission of individual characteristics- omitted covariates specific to the child and possibly distinct from those affecting other children in the sample (unmeasured heterogeneity at the child level). The second strand was concerned with unmeasured family characteristics affecting mortality risks of children born to a mother or a living in the same household (one or more shared *unobserved* covariates will induce a correlation between their mortality risks). In this literature the problem is referred to as the clustering problem (some elements of covariates in the household are not observed by the investigator, conditional on the observed characteristics or covariates, a residual correlation of responses defines this clustering problem (Cesar, Palloni, and Rafalimanana, 1997).

Cesar, Palloni, and Rafalimanana (1997) state that a distinctive marker of clustering of deaths is the over-dispersion of responses since mortality risks for children of the same family are more alike than those from different families; over-dispersion is term for greater variation than is expected from a conventional model that assumes independence between outcomes. Palloni (1990) argues it would be possible to address this problem by attempting to disentangle effects operating at different levels- that is a child level and a family level.

There might be serious consequences when a higher level of variation is ignored - this over-emphasis the magnitude of the random-effects at lower levels. Findings from Brazilian data on post-neonatal mortality by Curtis, Diamond, and McDonald (1993) show a highly significant familial variation in the risk of post-natal mortality. In simple terms, the probability of death for children with the same characteristics varies across families because it depends on the unobserved family effect (unmeasured heterogeneity).

But such a differential may be shared by the community at large and less likely by only one household. Sastry's (1997) work with the same Brazilian data further reveals that familial-effect shown by Curtis, Diamond, and McDonald (1993) is biased upwards because it incorporates the effects of environmental factors that are common not only to all children in the same family, but to all children residing in the same community. The familial-effect was overstated by a factor of four when unobserved community-effects are ignored and becomes insignificant once community-effects are controlled for (Sastry, 1997).

Ultimately, such a finding may also hold, in the analysis to follow since households share what local communities can offer given public health, access to basic needs of clean water, sanitation and distribution of income growth.

With the analytics of this study, the aims are to re-visit previous definitions of high risk families and to create new measures of familial-history of mortality (with the use of time-varying risk covariates). On formulating an analytical model of the latter, the third objective is to compare it with models that target accounting of unobservable or unmeasured heterogeneity or family-specific risk of mortality.

CHAPTER 4

ANALYSIS OF CHILD SURVIVAL USING LIFE-TABLES AND SINGLE-LEVEL MODELS

4.1 Introduction

In Chapter One, the thesis had introduced empirical findings of the trends and associates of childhood mortality declines in the three regions. Assessment of data quality of birth histories raised few issues with quality of date reporting, shifting of births back in time and omission of births. One consideration is to base the multivariate analyses following on mortality before age five as a cumulative measure least affected by data quality issues detected earlier, and limiting analysis to births born in the 15-year period before the survey.

In this chapter the thesis embarks on the analysis of mortality using statistical methods outlined in Chapter Three on maternity histories data. Maternity histories surveys have proved to be a very important source of information on levels trends, age patterns, and perhaps most significantly, associations with social, economic and biological factors (see, for example, Hobcraft, McDonald, and Rutstein, 1984).

In Section 4.2 and with the aid of life-table calculations, changes in estimates of mortality with respect to well-identified correlates are detailed, for birth cohorts provided by mothers' live-births histories. Three intervals of mortality were used, life-table estimates of mortality before age one, between ages one and five and, cumulatively before age five, respectively. As a natural progression from this comparison, models were postulated to adjust for the multivariate nature of the main correlates and the risks of death before five. A further dis-aggregation of these analyses was in applying logistic regression and Cox models for first and higher order births, separately, shown in Sections 4.3 and 4.4, respectively. In the title of this chapter, the term "Single-level models" is used to indicate that the model-based analyses of this chapter ignore the "structural" clustering of births history entries when they belong to the same mother or when households they dwell-in are clustered within the same geographical cluster. The comparative Section 4.5 subsumes findings from the two sets of model-based analyses in relation to empirical evidence available for each locality. With Section 4.6, a summary of the main findings is provided and discussed, finishing with an introduction to the multilevel analysis to follow.

Introducing the decline in childhood mortality levels are Figures 4.1.1 and 4.1.2 below, which depict trends in infant and under-5 mortality, respectively, for the 25-year period prior to the surveys.

Fig. 4.1.1 Trends in Infant Mortality Rates for 5-year Periods Preceding the Survey

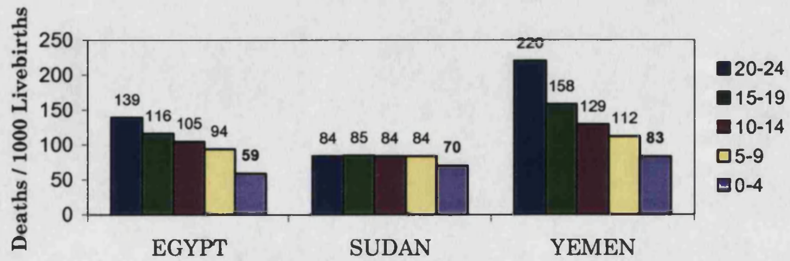
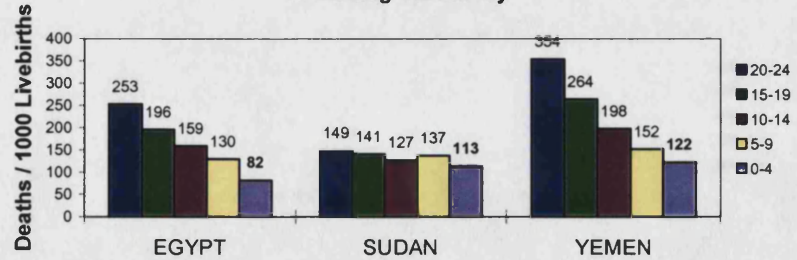


Figure 4.1.2 Trends in Under-5 Mortality for 5-year Periods Preceding the Survey



The three surveys almost followed one another, starting with Egypt's EMCHS in 1991, parallel to that Yemen's YDMCHS in 1991/92 followed by Sudan's SMCHS in 1992/93. Mortality rates for both figures are produced by a procedure for calculating synthetic cohort probabilities of death based on the procedure first developed by Somoza (1980) and modified by Rutstein (1984). For both measures of mortality, Egypt leads the group with the lowest estimates of infant and under-5 mortality. But the steepest declines belong to Yemen where mortality rates were roughly reduced to one-third comparing the periods 0-4 (late 1980s) and 20-24 (early 1970s) years before the survey. Both mortality rates reveal modest declines in the case of the Sudan for the 25-year period.

If countries are considered individually or collectively, attributes contributing to this decline are to a certain extent similar; as reviewed earlier in Chapter One. The sharp decline in Egypt in the mid-1980s coincided with a sharp rise in public and private investments in health. Similar period interventions were taking place in Sudan but no sharp falls followed. Yemen appears as a late starter with the highest levels of both measures but the steepest declines, with much more needed reductions.

4.2 Life-Tables Analysis

One of the mostly commonly used methods in demographic research is the life-tables method. To ascertain "period-changes" in mortality levels, maternity histories were used to calculate life tables estimates of childhood mortality for 5-year periods up to 25 years before the survey date. Table 4.2.1 presents a summary of 5-year period changes in the estimated death rates, at different ages across countries. Three main entries are presented; the first indicates the probability $_1q_0$ of a child's death before age one year, and the second indicates a conditional probability $_4q_1$ of a child's death before age five having survived to age one (or child mortality rate). The third type entry $_5q_0$ indicates the cumulative probability of death before an age five.

Though crucially different, estimates of infant mortality almost halved in Egypt and Yemen in the period between the early 1970s and the late 1980s. For example, infant mortality fell from 124 per thousand live births in the period 15-19 years before the survey to 58 per thousand live births in the period 0-4 years before the survey, respectively. In the case of Sudan, the period-estimates are, overall, lower than those found in both Egypt and Yemen, yet indicate a moderate decline of about 24 per cent for the period between the early 1970s and the mid 1980s (from 84 to 64 / 1000).

Table 4.2.1: Life-Table Estimates of Probabilities of death for 5-year bands preceding the Survey

Birth Cohorts Years Before The Survey	Probabilities of death $_nq_x$ (expressed as deaths / 1000 live births)								
	$_1q_0$			$_4q_1$			$_5q_0$		
	Egypt (%)	Sudan (%)	Yemen (%)	Egypt	Sudan	Yemen	Egypt (%)	Sudan (%)	Yemen (%)
0-4 *(late 1980s)*	58 (81)	64 (68)	78 (77)	14	31	23	72 (100)	94 (100)	102 (100)
5-9	97 (75)	87 (64)	109 (78)	32	48	31	129 (100)	135 (100)	140 (100)
10-14	109 (72)	85 (66)	125 (74)	43	43	45	151 (100)	128 (100)	170 (100)
15-19 *(early 1970s)*	124 (59)	84 (63)	147 (68)	70	51	70	194 (100)	134 (100)	217 (100)
20-24	141 (59)	95 (59)	185 (65)	101	66	97	241 (100)	161 (100)	283 (100)

Life-table estimates of child mortality ($_4q_1$), and with the exception of the most recent period, place Egypt and Yemen at similar level of the estimates and hence percentage declines. Between the early 1970s to the late 1980s, the average reduction is 80 per cent for Egypt (from 70 to 14 / 1000) and 67 per cent for Yemen (from 70 to 23 / 1000), respectively. For the same period, the average decline in the case of Sudan was 39 per cent (from 51 to 30 / 1000). This result flags issues of stagnation in mortality decline in the Sudan, given that the estimated levels of mortality for the early 1970s were better than those found for Egypt and Yemen for the same periods.

Considering estimates of the cumulative mortality before age five, the same observation can be made as that with estimates of infant mortality rates. Between the early 1970s and late 1980s, Egypt has managed to reduce under-five mortality by 63 per cent (from 194 to 72 / 1000) compared to Yemen's 53 per cent (from 217 to 102 / 1000). The elusive reduction for Sudan was only 30 per cent on average (from 134 to 94 / 1000).

One possible explanation for that perhaps lies with the fact that in the two decades before the survey, Egypt has managed to narrow most of early childhood losses to those before age one year (percentages shown in red, in Table 4.2.1). Yemen appears to be following a similar trend to that – perhaps these are the premptive effects of promotive public health activities. Perhaps, the extra threshold observed for Egypt are added benefits of the higher uptake of contraceptive use (prolonging birth intervals and curbing higher births numbers) characteristic of the early 1980s. The situation in Sudan, and for the two decades preceding the survey, shows death before age one constitute roughly about two-thirds of mortality before age five, which indicates slow rates of health improvements associated with the prenatal and post-neonatal period.

A closer examination of the risk of childhood death covaried by a number of bio-demographic and socio-economic factors follows in Tables 4.2.2 and 4.2.3, respectively. Here, relations are examined collectively for the 0-24 years period before the survey. It is worth noting at this point that two statistical tests, the log-likelihood ratio test and the log-rank test[6] were used to examine the significance of the bivariate relations presented, *all* of which showed high significance.

Variations in mortality risk between male and female children are expected for a number of reasons. In particular, biological factors predispose boys to higher risk of death, especially during infancy. However, behavioural factors may operate in the opposite direction in societies with strong son preference and where childcare differs by sex. Estimates of mortality before age one are higher for males than females as anticipated. Child mortality is slightly higher for females than males in Egypt perhaps suggestive of more preferential care for the latter gender. For estimates of

[6] ***ltable*** command options, pages 251-261, Stata 6.0 , Volume 2, Reference H-O, Stata Corp. (1999).

mortality before age five, Egypt shows a considerable difference in the risk of death for females compared to males (about 10 extra female death per a thousand live births), while for Sudan and Yemen the case is that of under reporting of female deaths resulting in seemingly higher death estimates for males (see differential sex ratio estimates at birth by survival status, p.86).

The expected relation of mortality rates to parity is that of increased risks for first births (a consequence of teenage pregnancies) and higher parities (birth orders greater than seven). What is of great interest is that the U-shaped (sometimes, J-shaped) relationship is apparent for the three societies, yet contrasts arise.

Table 4.2.2: Bio-demographic Differentials of Life-Table Probability of Death Estimates

		Probabilities of death $_nq_x$ (expressed as deaths / 1000 live births)								
		1q0			4q1			5q0		
Correlate	**Group**	Egypt	Sudan	Yemen	Egypt	Sudan	Yemen	Egypt	Sudan	Yemen
Sex	Male	107	88	127	46	50	44	153	137	171
	Female	102	77	111	61	46	50	163	124	161
Parity	First birth	104	94	136	50	44	43	153	137	179
	2nd - 3rd	99	74	122	49	47	53	148	121	175
	4th-6th	105	79	108	58	50	48	164	130	156
	7th+	124	92	116	56	51	40	180	143	156
Maternal Age at Birth	<18 years	167	108	173	86	59	57	253	167	230
	18-19	129	81	153	58	51	54	187	132	207
	20-24	110	80	121	55	49	51	165	129	172
	25-29	87	75	103	51	46	43	138	121	146
	30-34	82	75	99	39	42	41	120	117	140
	35 +	90	92	104	35	43	39	126	136	143
Previous Birth Interval	First birth	106	94	136	49	44	43	156	137	179
	< 18 Mons	202	139	178	93	80	70	294	219	248
	18-23	114	76	112	64	51	41	178	127	153
	24-35	74	68	66	44	41	34	118	109	100
	36+ Mons	44	43	50	21	29	21	65	72	70
Preceding Birth Survival Status	No	207	166	238	60	61	54	267	227	293
	Yes	86	69	94	50	46	45	136	116	139
Parity X Older Sibling Mortality	First births	104	94	136	50	44	43	153	137	179
	B2-3 X 0 death	90	69	116	47	45	50	137	113	165
	B4-6 X 0 death	77	63	80	46	39	41	123	102	121
	B7+ X 0 death	79	67	68	42	38	24	121	104	91
	B2-3 X 1+ death	189	134	187	69	75	85	257	210	272
	B4-6 X 1 deaths	130	101	137	63	65	55	193	165	192
	B7+ X 1 deaths	107	99	106	59	48	34	166	148	140
	B4-6 X 2+ deaths	153	137	162	90	91	62	243	227	225
	B7+ X 2+ deaths	146	115	147	59	67	51	205	181	197

Comparing all three probabilities of death, the highest estimates belong to birth parities of order seven and more; for Yemen higher mortality rates belong more to first births (commonly born to very young mothers). Less marked is the U-shaped relationship of parity with mortality rates in the case of the Sudan. Easier to observe is the L-shaped relation of higher death rates for very young (20 years and under) and older ages (35 years and older) at birth is clearly evident. The differential is marked in the cases of Egypt and Yemen where surely one in five births would die before age five if born to a mother aged less than 18 years.

Strikingly, life-table estimates of mortality (before age one, and cumulatively before age five) will more than halve for children with a surviving immediately preceding sibling. Associated with the above is the length of the preceding birth interval. Here, estimates of mortality are monotonic – prolonged birth intervals result in the lowest estimates of mortality for the two survival ages. Prolonged birth intervals of 36 months and more closes the gap between estimates of age-specific mortality cross-countries.

The last bio-demographic factor to consider is the complex interaction term between the index child's birth order (grouped) and counts of older siblings deaths excluding the immediately previous birth. The design of this factor will be explained in greater detail in Section 4.4 to follow. Shown elsewhere (in Section 4.4), the most prevalent group in these samples is birth order group 2-3 with no counts of previous mortality accounting for almost one-third of births. Yet the lowest life-table estimates of infant mortality belong to birth order group 4-6 with no counts of previous mortality in the Sudan and Egypt. For Yemen, the lowest infant mortality rate is found with birth order group 7+ with no counts of previous mortality. The highest death rate estimates in Sudan belong to the birth order group 4-6 with 2 or more older deaths. At a comparable percentage the highest death rate for Egypt and Yemen are for birth order group 2-3 with 1 count of death. The complex interaction terms "screen" familial-mortality risks of the household environmental more pertinent to the time of birth of the index child. These associations are more or less repeated for estimates of mortality before age five.

Turning to consider some of the socio-economic indicators (shown by Table 4.2.2. below) collected mainly from the women's survey, starting with the classification of the area of residence as urban or rural. The residential differential appear sharpest in the case of Egypt, where life-table estimates of infant mortality are one third higher for births born in rural areas compared to those born in urban areas. Estimates of child mortality in Egypt are 75 per cent higher for births born in rural areas – which further emphasises the socio-economic divide between the two regions. Estimates of early childhood mortality are expected to be lower for births born to mothers who had some schooling. About two third of births in Egypt and Sudan are to mothers with some schooling, while for Yemen, less than 10 per cent of births are to mothers with some schooling. In early childhood, the widest differential of mortality risks attributable to the advantage of mothers schooling is between age one and five.

Table 4.2.3: Socio-economic Differentials of Life-Table Probability of Death Estimates

		Probabilities of death $_nq_x$ (expressed as deaths / 1000 live births)								
			$_1q_0$			$_4q_1$			$_5q_0$	
Correlate	Group	Egypt	Sudan	Yemen	Egypt	Sudan	Yemen	Egypt	Sudan	Yemen
Area of Residence	Urban	88	77	118	36	35	38	124	112	156
	Rural	115	86	120	63	55	50	178	141	170
Mother Attended School	No	116	90	123	64	59	50	181	149	172
	Yes	82	66	75	30	24	14	111	90	89
Husband Attended Schooling	No	121	91	130	70	63	54	191	154	184
	Yes	89	72	90	36	28	25	125	100	114
Husband Works in Agriculture	No	96	80	112	44	42	40	140	121	152
	Yes	120	88	136	69	58	62	189	146	198
Regions	1)	87	73	127	30	30	53	117	103	180
	2)	75	87	96	37	67	28	112	153	125
	3)	95	81		52	46		146	127	
	4)	103	99		47	66		150	165	
	5)	139	77		76	42		215	120	
	6)		87			46			133	
Clusters' Type of Sanitation	Toilet	96	88	107	47	66	32	144	154	139
	Pit/Latr	147	82	126	71	42	47	218	124	173
	Open Air	97	67	118	62	22	54	159	89	172
Clusters' Water Supply	Piped	99	84	119	50	73	41	149	157	160
	Pumped	126	86	117	64	51	47	190	137	165
	Other		77	125		32	59		109	184
Clusters' Utility	Electricity	105	77	115	53	33	39	158	110	154
	Kerosene	95	86	125	52	56	57	147	142	182

Regions:

Egypt: 1) Urban Governates, 2) Urban Lower, 3) Rural Lower, 4) Urban Upper, 5) Rural Upper
Sudan: 1) Khartoum, 2) Eastern, 3) Central, 4) Darfur, 5) Kordofan, 6) Northern
Yemen: 1) North and West, 2) South and East.

Despite Yemen's low percentage of births to mothers with some schooling, the probability of death for a child before age five, having survived to age one is less than a third of that estimated for births born to unschooled mothers. A similar scenario applies with the paternal education differential; here husbands with some schooling, are expected to bear better economic and social support to the upbringing setting. Cumulatively, estimates of mortality before age five are reduced at the very least by a third for children of fathers with some schooling, and having survived the first year of life, risks of mortality between age one and five are almost halved.

Regrouping the original item into whether or not the husbands worked in agriculture represented the occupation of husbands. Husbands' work in agricultural contributes to higher estimates of mortality especially before age one. For that age, estimates of mortality are lower roughly by a third for births born to mothers whose husbands work in non-agricultural occupations.

A key socio-economic indicator current in all three countries is the intra-country region-of-residence differential; 5 regions in Egypt, 6 governates in Sudan and 2 broader regions in Yemen, respectively. Consistently, and cross-sectionally, residence in the Upper Rural region in Egypt, Darfur governate in Sudan and the North and West in Yemen bear the higher intra-regional estimates of mortality. In the case of Egypt, the life-table estimates of mortality for the Upper Rural region are almost double those of the Urban Governates. For Darfur, mortality estimates, especially post age one, are double those of the advantaged "Khartoum" region. For Yemen, the North and West region estimates of mortality between age one and five are close to double those estimated for the South and East region.

So far, the socio-economic characteristics reviewed relate directly to the mother or the household these births are born to. To tap on what could be termed as community effects, three new factors were constructed by *collapsing* information on household amenities collected in the housing survey. These are collectively termed "cluster-characteristics" describing the clusters' utility or electricity supply, sanitation and source of water. Surely, individual households may still differ in utilities makeup within clusters, but these captures measure cluster conditions around households. Further, measurements taken on household at the time of the survey, will not necessarily pertain to conditions at the time of birth especially for older children.

Starting with the cluster's type of sanitation, the three countries vary considerably in the distribution of planned sanitation. The differential appears sharpest only for Egypt, where estimates of under one mortality for births born in clusters with "Toilet" sanitation are one-third less compared to those births born in clusters with "Pit / Latrine" sanitation. An advantage which persists all through to survival to age five years. To some extent, in the case of Yemen, clusters with "Toilet / Shared" sanitation bear better survival rates to births born and living there compared to clusters relying on "Pit / Latrine" or "Open Air" sanitation.

With the cluster's water supply, lower estimates of mortality rates are expected where the main cluster water supply is through a government's piped source. Consistent effects are perhaps found only in the case of Egypt, where births living in clusters with access to piped water have a one-fifth reduction in their estimates of mortality before age one (and further before age five, respectively).

A third index of the level of development for these localities is the cluster's electricity supply; through-out early childhood mortality, the lowest estimates are found in Sudan, when births are residing in clusters with electricity supply. Egypt shows slightly higher mortality estimates for clusters with rather than without electricity. Critically, the sharpest differential is born by Yemen when mortality estimates beyond age one (and before age five) is concerned; for that death age, estimates for clusters with electricity are 40 per cent lower compared to other clusters with no electricity.

In summary, all bivariate relations examined resulted in significant evidence of variability between groups and in the anticipated direction of influence. Higher death rates were estimated for female births (with the exception of Egypt), births born to very young or older mothers, of higher parity, following shorter birth intervals, and those born to mothers who lost older children.

Advantaged settings with better socio-economic indicators have smaller estimated death rates cross-countries. Lower childhood mortality was estimated for urban areas, where mothers had some schooling, where husbands had some schooling and where husbands worked in a non-agricultural occupation. Three indices of cluster-characteristics similarly confirm lower estimated death rates for clusters with planned sanitation, piped water supply and electricity supply in the three settings.

Consequential to the identification of bivariate associations is the progression into a multivariate framework. As reviewed earlier in Chapter Three, model-based generalised linear models permit the determination of the effect of each of the potential predictor variables while controlling for other variables (i.e. holding them constant).

In Sections 4.3 and 4.4, two methods of analysis will be used, the logistic regression model and the Cox model. The latter method is deployed to further insert time-varying effects of extra mortality events after the birth of the index child and the status of a subsequent birth effects on both survival chances. Using the Cox model also ameliorates the need to exclude recent births due to right censoring of their survival experience by the time of the survey.

The survey-design adjusted logistic regression model is applied to the cohort of *singleton* births born 5-15 years before the survey date, for the analysis of survival to age five. The cut-off of 15 years before the survey should reduce the effects of reporting errors associated more with births born in earlier years.

Section 4.3. is concerned with analysis of mortality of first births. Section 4.4. with the analysis of mortality of higher order births, respectively.

4.3 Analysis of First Births Survival to Age 5

First births are those births recorded as the first live-births entry in mothers' births histories. Guided by empirical research evidence, first births are characterised by young maternal ages at birth and in many settings a gender bias in mortality rates favouring male first births over their counterparts. With the young maternal age at birth, other effects would manifest such as low levels of mothers schooling, rural residence and hence lower socio-economic *survival* settings for first births.

4.3.1 Time-invariant Correlates of First Births Survival to Age 5

Following the life-table expository analysis, the first of multivariate model-based analysis is presented in Table 4.3.1 below. All of the explanatory variables introduced to models were categorical variables. Therefore, with respect to a base-line group, groups of increased risks yield Odds Ratios (OR) larger than 1.0 and groups of reduced risks yield ORs less than 1.0, respectively. Table 4.3.1 shows results of logistic regression of mortality before age five on two bio-demographic and four socio-economic indicators adjusting for period changes.

Table 4.3.1 : Comparative, Survey-design Adjusted Odds Ratios (OR) of Survival to age 5 (First-Births)

Correlates	Egypt (1991) N=3326 %	Egypt OR	Egypt (95 % C.I.)	Sudan (1992/93) N=1646 %	Sudan OR	Sudan (95 % C.I.)	Yemen (1991/92) N=2391 %	Yemen OR	Yemen (95 % C.I.)
Sex									
Male	52.7	1.14	(0.93,1.41)	52.9	1.38**	(1.00,1.90)	51.0	1.34**	1.07,1.69)
Female (Ref)	47.3	1.00		47.1	1.00		49.0	1.00	
Mother's age at birth									
< 18 years	22.0	1.51***	(1.15,1.97)	33.2	1.28	(0.89,1.83)	33.3	1.30*	(0.99,1.70)
18-19 years	20.5	0.88	(0.65,1.20)	19.8	1.16	(0.74,1.81)	19.5	0.95	(0.67,1.35)
20-24 (Ref)	37.6	1.00		32.2	1.00		31.6	1.00	
25-29	15.7	0.59***	(0.40,0.88)	11.2	0.78	(0.42,1.47)	9.7	0.74	(0.48,1.14)
30-34	3.2	1.19	(0.65,2.18)	3.0	0.52	(0.16,1.73)	4.2	1.42	(0.86,2.35)
35 +	1.0	1.13	(0.33,3.84)	0.6	0.87	(0.09,8.22)	1.7	0.80	(0.24,2.65)
Area of residence									
Urban (Ref)	39.5	1.00		36.5	1.00		22.7	1.00	
Rural	60.5	1.57***	(1.18,2.10)	63.5	1.24	(0.85,1.81)	77.3	1.08	(0.73,1.61)
Mother attended School									
No	54.7	1.44**	(1.08,1.91)	51.3	0.97	(0.65,1.44)	85.5	1.52	(0.89,2.58)
Yes (Ref)	45.3	1.00		48.7	1.00		14.5	1.00	
Husband attended School									
No	28.0	1.13	(0.88,1.45)	41.3	2.09***	(1.40,3.11)	74.3	1.08	(0.81,1.45)
Yes (Ref)	72.0	1.00		58.7	1.00		25.7	1.00	
Husband in Agriculture									
No (Ref)	64.0	1.00		67.4	1.00		60.9	1.00	
Yes	36.0	1.07	(0.82,1.39)	32.6	0.70*	(0.48,1.02)	39.1	1.42***	(1.09,1.86)
Years Before Survey									
"5-9" (Ref)	50.6	1.00		53.3	1.00		48.7	1.00	
"10-14"	49.4	1.17	(0.95,1.44)	46.7	0.81	(0.60,1.11)	51.3	1.12	(0.86,1.46)

*** sig. at 0.1%, ** sig. at 5%, * sig. at 10%; *Ref: Reference Group*

Empirical evidence characterises male births with an innate biological disadvantage leading to lower survival rates especially in the first year of life. Amongst first births, males appear to bear a one-third rise in risks of death before age five in the case of Sudan and Yemen as compared to their female counterparts. This result is not surprising given the evidence of under-reporting of female deaths detected by the quality of data assessment.

Young maternal age at first birth (less than 18 years) has considerable prevalence and poses greater risks on survival chances to age five more so in Egypt (where risks are increased by 51 per cent). In the case of Yemen, though marginally significant the risk of death before may increased by 30 per cent, when the mothers' age at first birth is less than 18 years. Though in the right order, effects of maternal age on survival chances show no significance in the case of the Sudan, which could be in part due to the presence of key controls in the model. The protective effects of later maternal ages at first birth are sharpest once again in Egypt, where a mothers' age at first birth of 25-29 would reduce the risk of a child's death before age five by at least two-fifth when compared to a maternal age of 20-24 years.

First births survival chances are expected to be better in urban areas compared to rural settings. Surprisingly, this differential showed significance only for Egypt where the estimated parameter associated with rural residence shows 57 per cent excess risk of death before age five for first births compared to those in urban areas.

First births born to mothers with some years of schooling are expected to have better survival chances compared to those whose mothers had no schooling at all. The percentage of births to mothers with no schooling is highest in Yemen (85 per cent), followed by Egypt (55 per cent) and Sudan (51 per cent). Significant only in the case of Egypt, first births born to mothers with no schooling carry slightly more than two-fifth the risk of death before age five compared to those born to mother with some schooling years. The lacking beneficial effects of mothers schooling in the case of Sudan is a product of the confounding effect of husbands' schooling in the multivariate relation discussed below.

Husbands (or fathers) with some schooling are expected to have better employment options, and bear the remittance of a better socio-economic status. In Sudan, births to women whose husbands had no schooling have the pervasive disadvantage of slightly more than a two-fold increase in the risk of death before age five compared to their counterparts.

First births to Yemeni women whose husbands work in agriculture have two-fifth greater risk of death before age five compared to those born to mothers whose husbands are in non-agricultural jobs. In the case of Sudan, some contradictory, but marginally significant, evidence is encountered where births born to mothers whose husbands are in agriculture carry 30 per cent less risk of death before age five.

Next to review are the results of the Cox model analysis with the addition of two extra variables.

4.3.2 *Selective Time-varying Correlates of First births Survival to age 5*

As stated elsewhere in Chapter Three, the *exponentiated* Cox model estimates are approximate relative risks (RR), shown by Table 4.3.2 in the next page. With the Cox model, two relative additions are the "Period-effects" and the time-varying factor, the status of the subsequent birth. Initially, as with the analysis using the survey-design adjusted logistic regression, the Cox model was applied only to births born in the period 5-15 years before the survey. What was observed is that the results of the Cox model that included birth born in the recent period, "0-4" years before the survey, were almost identical to those of the model that excluded them. Hence, a choice was made to keep the extended sub-sample for better representation of period changes.

Table 4.3.2 : Comparative Relative Risks (RR) of Survival to age 5 (First-Births)

Correlates	Egypt (1991) N=5061 (%)	Egypt (1991) Cox Model RR (95% C.I.)	Sudan (1992/93) N=2476 (%)	Sudan (1992/93) Cox Model RR (95 % C.I.)	Yemen (1991/92) N=3303 (%)	Yemen (1991/92) Cox Model RR (95 % C.I.)
Sex						
Male	52.5	1.13 (0.95,1.34)	52.1	1.16 (0.92,1.45)	51.4	1.34*** (1.13,1.59)
Female (Ref)	47.5	1.00	47.9	1.00	48.6	1.00
Mother's age at birth						
< 18 years	19.6	1.53*** (1.23,1.9)	27.9	1.26 (0.95,1.68)	30.6	1.33*** (1.08,1.64)
18-19 years	21.2	0.95 (0.75,1.22)	19.2	1.17 (0.85,1.6)	19.4	1.09 (0.85,1.41)
20-24 (Ref)	38.9	1.00	35.8	1.00	33.9	1.00
25-29	15.9	0.73* (0.53,1)	12.8	0.82 (0.53,1.25)	10.8	0.90 (0.64,1.26)
30-34	3.4	1.04 (0.61,1.77)	3.5	0.64 (0.28,1.45)	3.8	1.32 (0.87,.200)
35 +	1.0	2.03* (0.96,4.28)	0.8	1.40 (0.45,4.39)	1.4	1.11 (0.52,2.39)
Area of residence						
Urban (Ref)	38.9	1.00	36.5	1.00	23.7	1.00
Rural	61.1	1.54*** (1.21,1.95)	63.5	1.15 (0.87,1.54)	76.3	1.09 (0.83,1.44)
Mother attended School						
No	51.6	1.24* (0.99,1.56)	52.6	1.26 (0.94,1.70)	82.0	1.43* (0.99,2.06)
Yes (Ref)	48.4	1.00	47.4	1.00	18.0	1.00
Husband attended School						
No	33.3	1.17 (0.95,1.44)	38.2	1.51***(1.14,2.01)	44.3	1.14 (0.92,1.41)
Yes (Ref)	66.7	1.00	61.8	1.00	55.6	1.00
Husband in Agriculture						
No (Ref)	71.2	1.00	69.1	1.00	75.1	1.00
Yes	28.8	1.10 (0.9,1.35)	30.9	0.84 (0.63,1.11)	24.9	1.29*** (1.07,1.56)
Years Before Survey						
"0-4"	34.2	0.63*** (0.5,0.8)	33.5	1.14 (0.86,1.52)	27.6	0.52*** (0.4,0.67)
"5-9" (Ref)	33.3	1.00	35.5	1.00	35.3	1.00
"10-14"	32.5	1.14 (0.95,1.38)	36.0	0.84 (0.64,1.11)	37.1	1.05 (0.87,1.27)
Status Subsequent Birth						
0 = None (Ref)	49.6	1.00	49.5	1.00	50.3	1.00
1 = Conception	26.1	2.52*** (1.92,3.32)	25.2	1.77***(1.17,2.69)	24.3	0.92 (0.66,1.29)
2 = Birth	22.0	1.85** (1.06,3.23)	23.7	1.19 (0.58,2.45)	22.5	0.84 (0.47,1.51)
3 = Death	2.3	2.60* (0.98,6.85)	1.6	3.99***(1.61,9.90)	2.9	1.17 (0.48,2.83)

*** sig. at 0.1%, ** sig. at 5%, * sig. at 10%; ***Ref: Reference Group***

Period-changes in mortality levels are introduced to the models via the variable "Years before the survey" which defines *three* 5-year periods before the survey time.

Cross-countries choosing the period "5-9" years before the survey as the baseline period, roughly corresponds to the period of the early 1980s. In the recent period, that is the late 1980s or "0-4" years before the survey, first births mortality risks appear to have reduced by one-third for Egyptian first births and close to a half in the case of Yemen, with a troubled indicator of slightly increased risks in the case of Sudan. With the analysis of first births, one time-varying variable applies and that is the status of the subsequent pregnancy. The variable changes values as the status changes from no conception, to conception, to a birth and to a death of a subsequent birth, respectively, in the first 60 months of life exposure time. Compared to a state of no subsequent conception, excess risks of first births mortality before age five escalate to two and half-times in the case of Egypt, and, by 77 per cent in the case of Sudan, respectively. Yet, no extra risks are reported in the case of Yemen. With a subsequent birth, excess risks persist at an attenuated level only in the case of Egypt. Though rare but more interesting is the comparison when a subsequent birth dies – excess risks of death for the index child are close to four-fold in the case of Sudan, and marginally moderate in the case of Egypt, compared to a state of no conception.

Still, the differential lacks in magnitude and significance in the case of Yemen. One observation to make is that the percentages shown next to the variable "Status Subsequent Birth" represent the status of the subsequent birth at the end of exposure period, which is 60 months with survival to age five. The distribution of the variable is quite similar cross-countries. For example, taking the distribution of first births followed by a conception by its fifth birthday, the percentages are 25 , 26 and 25 for Egypt, Sudan and Yemen, respectively. Yet, associations differ in the three settings.

In summary, first births carry a considerable risk of early childhood death when born to younger and older mothers especially in Egypt and Yemen, with the lowest risks showing when mothers' ages at first births are between 20 – 29 years. There was a sex differential in mortality detected in Sudan and Yemen, which could be largely due to the underreporting of dead female first births.

So far as socio-economic differentials are concerned, the variables combine differently for each country. In Egypt, rural settings and mothers with no schooling characterise higher risk first births. In Sudan, first births born to mothers whose husbands had no schooling have a close to doubled risk of death compared to those born to their counterparts. And in Yemen the strongest socio-economic differential lowering children's survival chances is that associated with fathers' employment in agriculture. Lastly, controlling for time-effects ascertain lower mortality risks for first births with more recent periods in the cases of Egypt and Yemen, and almost absent in the case of Sudan. Subsequent births are inevitable especially after first births and do constitute considerable extra risks at all stages of conception, birth and worth still death, evident of perhaps siblings' competition for maternal care and resources.

4.4 Analysis of Higher-order Births Survival to Age 5

Higher-order births are births entries of birth order two or higher. Compared to first births, higher-order births can be further characterised by an added number of bio-demographic variables. Starting with parity or birth order, mortality risks increase with birth order as a non-linear relationship- often represented by a categorical indicator of birth order groups. Using information on the dates of birth (and death), preceding birth intervals can be calculated between adjacent births. Added to that, indicators of the survival status of the immediately previous sibling and counts of older siblings fatalities can be quantified. As with the former analysis of first births, this section carries the interpretation of two model-based comparative analyses of time-invariant and time-variants associations of higher-order births survival chances to age five, respectively.

4.4.1 Time-invariant Correlates of Higher-order Births Survival to Age 5

Table 4.4.1 (in the next page) shows results of logistic regression of mortality before age five on five bio-demographic and four socio-economic indicators adjusting for period changes. Starting with gender, and as discussed earlier with first births, one would expect to find evidence of poorer survival rates for male compared to female later births, especially in the first year of life. Estimates of excess risks are significant in the case of Sudan, showing higher order male births with a one-fifth increase in the risks of mortality before age five compared to their counterpart females. In the case of Yemen, some marginally significant increase of 12 per cent extra risk was estimated for male births with survival chances to age five. In the case of Egypt, male higher order births appear with a slim advantage in survival chances possibly suggestive of slight preferential treatment.

Table 4.4.1 : Comparative, Survey-design Adjusted Odds Ratios (OR) of Survival to age 5 (Higher-Order Births)

Correlates	Egypt (1991) N=13263 %	Egypt (1991) OR (95 % C.I.)	Sudan (1992/93) N=8498 %	Sudan (1992/93) OR (95 % C.I.)	Yemen (1991/92) N=12703 %	Yemen (1991/92) OR (95 % C.I.)
Sex						
Male	51.2	0.94 (0.84,1.06)	51.6	1.19***(1.05,1.36)	52.0	1.12* (1.00,1.27)
Female (Ref)	48.8	1.00	48.5	1.00	48.0	1.00
Mother's age at birth						
< 18 years	2.7	1.44***(1.09,1.90)	3.6	1.25 (0.88,1.77)	4.3	1.10 (0.85,1.41)
18-19 years	5.1	1.03 (0.81,1.32)	5.9	0.88 (0.65,1.19)	6.9	0.91 (0.72,1.16)
20-24 (Ref)	27.0	1.00	25.7	1.00	26.4	1.00
25-29	29.7	0.89 (0.77,1.03)	27.4	0.99 (0.81,1.20)	26.5	0.88* (0.77,1.01)
30-34	21.4	0.81** (0.68,0.98)	21.0	1.04 (0.84,1.29)	18.7	0.85* (0.72,1.01)
35 +	14.0	0.91 (0.75,1.11)	16.3	1.19 (0.91,1.56)	17.3	0.96 (0.77,1.18)
Previous Birth Interval						
< 18 months	24.0	2.80***(2.44,3.22)	26.1	2.43***(2.03,2.90)	44.8	2.80***(2.35,3.34)
18-23 months	17.4	1.50***(1.28,1.75)	18.5	1.19* (0.98,1.44)	17.5	1.59***(1.29,1.96)
24-35 months (Ref)	28.7	1.00	32.2	1.00	20.8	1.00
36+ months	29.8	0.57***(0.48,0.66)	23.2	0.69***(0.55,0.87)	16.9	0.58***(0.45,0.75)
Birth Order X Previous Deaths						
B2-3 X 0 deaths (Ref)	39.8	1.00	33.1	1.00	32.3	1.00
B4-6 X 0 deaths	20.9	1.07 (0.91,1.26)	25.9	0.87 (0.71,1.06)	22.8	0.76***(0.64,0.90)
B7+ X 0 deaths	3.3	1.54***(1.11,2.14)	9.7	0.81 (0.57,1.15)	5.7	0.69** (0.49,0.97)
B2-3 X 1 death	3.4	1.81***(1.40,2.35)	2.5	1.66** (1.10,2.50)	3.1	1.32* (0.98,1.77)
B4-6 X 1 death	12.0	1.79***(1.50,2.15)	9.8	1.35** (1.04,1.76)	11.5	1.27** (1.05,1.52)
B7+ X 1 death	4.6	1.55***(1.18,2.04)	7.1	1.08 (0.78,1.50)	6.3	1.21* (0.97,1.52)
B4-6 X 2+ deaths	5.4	2.11***(1.67,2.65)	3.4	1.31 (0.89,1.93)	5.7	1.03 (0.79,1.33)
B7+ X 2+ deaths	10.6	1.96***(1.60,2.39)	8.6	1.24 (0.90,1.72)	12.5	1.31** (1.04,1.64)
Previous Child Survived to Birth of Index Child						
Yes (Ref)	85.9	1.00	90.0	1.00	85.4	1.00
No	14.1	1.50***(1.31,1.71)	10.0	1.68***(1.42,1.99)	14.6	1.89***(1.62,2.21)
Area of residence						
Urban (Ref)	34.2	1.00	33.4	1.00	23.4	1.00
Rural	65.9	1.26***(1.08,1.47)	66.6	0.96 (0.81,1.15)	76.6	1.06 (0.87,1.30)
Mother attended School						
No	69.5	1.26***(1.09,1.47)	70.4	1.39***(1.12,1.72)	94.1	1.27 (0.93,1.73)
Yes (Ref)	30.5	1.00	29.6	1.00	5.9	1.00
Husband attended School						
No	63.7	1.17***(1.04,1.32)	40.4	1.37***(1.12,1.67)	68.0	1.24***(1.07,1.45)
Yes (Ref)	36.3	1.00	59.6	1.00	32.0	1.00
Husband in Agriculture						
No (Ref)	50.0	1.00	42.6	1.00	75.7	1.00
Yes	50.0	0.96 (0.85,1.09)	57.4	1.06 (0.91,1.24)	24.3	1.12 (0.98,1.28)
Years Before Survey						
"5-9" (Ref)	51.4	1.00	55.2	1.00	57.8	1.00
"10-14"	48.6	1.09* (0.98,1.22)	44.8	0.95 (0.83,1.10)	42.2	1.29***(1.14,1.45)

*** sig. at 0.1%, ** sig. at 5%, * sig. at 10%; ***Ref: Reference Group***

Young maternal age with higher order births is less common but significant extra risks feature in the model for Egypt, with and estimate of 44 per cent excess risk with a mother's age at a later birth is less than 18 years. Cross-countries, second and higher births to very young mothers are rare (about 10 per cent) and few of the individual parameter estimates are statistically significantly different from the reference group of 20-24-years-old-mothers. The models bear a strong suggestion that survival chances for children improve slowly with increasing age of mother beyond age 18 up to age 35, perhaps more confined to the age group 30-34. Compared with children born to 20-24-year-old mothers, the overall average deviations in the odds ratios suggests a significant 19 per cent and a marginally significant 15 per cent net decrease in risks for births to 30-34-year-old mothers in Egypt and Yemen, respectively. For the Sudan, the correlate estimates testify to the U-shaped relationship between survival chances and mothers' age at births, but none of the coefficient estimates is significant.

One deterministic factor of a child's survival chances is the length of the birth interval preceding his /her birth. Shorter preceding birth intervals of less than 18 months are associated with considerable excess mortality by age five for the index child, in comparison with the reference group where preceding birth intervals are 24-35 months long. This threshold was chosen since close to one quarter of higher-order births in Egypt and Sudan followed birth intervals of length less than 18 months. In Yemen, 45 per cent of higher-order births follow a birth interval of less than 18 months. Compared to birth intervals of 24-35 months, the risk of death before age five years is close to trebled for later births following these short birth intervals in Egypt and Yemen, whilst the risk estimates in Sudan are slightly lower yet highly significant. Where the length of the preceding birth interval is 18-23 month the excess mortality risks are generally higher but overall lower than those experienced with birth intervals of less than 18 months. Excess mortality associated with shorter preceding birth intervals is hence substantial and pervasive. A consistent survival advantage is associated with birth intervals in excess of three years; reducing excess mortality by at least one third. Long intervals are the exception in these settings (23 per cent in Sudan and 17 per cent in Yemen) especially in a setting where contraceptive use is so low. Hence, longer birth intervals are probably the result of low fecundability or of contraception failure where it exists, or what could be differential omission of mis-carriages or dead children. Yet such events need not be very high in order to wipe-out the apparent survival advantage associated with this group (Hobcraft, 1994).

Turning to previous mortality among the older siblings of the index child. These measures draw heavily on the precision of the date of occurrence of a child death for the preceding births. These are death events of older siblings in the family previous to the birth of the index birth expressed as interaction terms with the birth order group of the index birth. Higher-order births especially in a family setting characterised by short birth intervals will further underpin such effects.

Almost without exception, the survival status of the immediately preceding sibling of index later births is a set marker of the survival chances of the latter. With this variable care was taken to avoid uncertainty surrounding the category of preceding children who "may be" dead due to imprecise dating, and were hence allocated a missing value for the covariate. About 10 per cent of higher-order births in the Sudan, and 14 per cent of higher-order births in Egypt and Yemen, respectively, followed the death of their immediately previous sibling. In the cases of Sudan and Yemen, the odds of death before age five are at least two-thirds higher for index later births born subsequent to the death of their immediately preceding sibling. For later births in Egypt, the estimate of excess risks is slightly smaller but remain highly significant

Over and above the risk indicated by the death of the immediately previous sibling death, extra risks are indicated where there is more of a familial history of child losses. To convey a fuller impression of the meaning of "clustering", these are death events of older siblings in the family previous to the birth of the index birth expressed as interaction terms with the parity group of the index birth. This parity-based measure is divided into three groups, a low-risk group (birth order 2-3), medium-risk group (birth order 4-6) and high-risk group (birth order 7+). For the low-risk group either 0 or 1 count of older death can be the case; for the medium and high-risk groups, 0, 1 or 2(+) older death counts are plausible. Cross countries and measures of mortality, the most prevalent interaction term is the birth order 2-3 with no count of older siblings deaths, hence used as a baseline category. To clarify the discussion Fig. 4.4.1 presented below relates the birth order groups with the counts of deaths of older siblings (prior to the immediately previous birth), reporting on estimates odds ratios from the survey logistic regression of Table 4.4.1. The odds ratio estimates shown are the results of the main effects multiplied by the original interaction terms obtained.

Fig. 4.4.1 Estimates of the Odds Ratios for the Interaction of Birth-order groups with counts of older siblings (previous to the preceding birth) Deaths

Birth Order Groups	Egypt			Sudan			Yemen		
	0	1	2 (+)	0	1	2 (+)	0	1	2 (+)
2-3	1.00	1.81***	--	1.00	1.66**	--	1.00	1.32*	--
4-6	1.07	1.79***	2.11***	0.87	1.35**	1.31	0.76***	1.27**	1.03
7+	1.54***	1.55***	1.96***	0.81	1.08	1.24	0.69**	1.21*	1.31**

*** Sig. at 0.1%, ** Sig. at 5%,* Sig. at 10%,

A state of no previous deaths with birth order groups 4-6 and 7+ compared to the reference parity group 2-3, could perhaps imply familial-settings of high fertility, and fewer "child losses" in Sudan and Yemen, but not Egypt. For fourth to sixth births, where all "earlier" births are alive, there are significant lower mortality differences compared with the reference group, that is second or third birth with a surviving first sibling. Similarly, for seventh and higher order births where no earlier child died, putative of an advantaged family survival background, there are clear indications of lower mortality risks in Sudan and Yemen, indicating mortality of intermediate births is acting to reduce siblings' competition for higher order births! Whilst in the case of Egypt, estimates are towards more than average risks of death especially for birth order seven and higher.

Of the total sample, less than five per cent of later births are in the birth order 2-3 experiencing 1 older sibling death, hence parameter estimates have large standard errors. For index children who are second or third births, the odds of death are increased by about 81 per cent in Egypt and 66 per cent in Sudan, respectively, if the first born child died, compared with the reference group in this context, which contains all second and third births with a surviving first birth. For fourth to sixth births where one earlier birth had died prior to the birth of the index child, and compared to the same reference group, the average odds of death are increased by about 79 per cent in Egypt which is higher than the estimates of 35 per cent in Sudan and 27 per cent in Yemen, respectively. Where the index child is a seventh or higher order birth, one death among the five or more earlier births is only unsurprisingly associated with a small average excess mortality for the index child and significant only in the case of Egypt. Remaining with the latter, compared to the baseline category, births orders two or three with surviving older siblings, excess mortality is almost doubled when two or more of these children had died prior to fourth and higher index births, respectively. In Yemen, the highest and most significant excess risk is apparent with birth orders seven and higher with two or more counts of older siblings deaths.

It can be further noted that the odds ratio associated with all the categories identifying non-surviving earlier births are generally greater than one, with no fewer than nine out of a possible twelve coefficients (shaded cells in Fig. 4.4.1) being significantly different from one (p-value < 0.05). By and large, events of deaths of older siblings are systematic and clear indicators of familial settings of higher exposure to child loss; stronger in Egypt in comparison to the Sudan and Yemen.

Four socio-economic indicators are included in the models of Table 4.4.1 (page 146). Although most of the socio-economic indicators information collected at the time of the survey are less pertinent to the time of birth of these cohorts, many proxies still serve as fair indicators of key differentials. Differentials such as area of residence (urban / rural), mothers schooling (none / some) and husbands schooling (none / some) influence chances of child survival. Child's survival rates vary by area of residence in almost all developing country settings. Surprisingly, and only significant for Egypt, the average increased risk of death before age five is one-quarter higher for births born and living in rural areas compared to those residing in urban areas. In the case of Sudan and Yemen, the weaker residential divide in survival experience is blanketed by the crucial presence of parental schooling and husbands' occupation in the multivariate model.

Whether a mother had some schooling should promise better survival chances for her children in the three settings. In the case of Egypt, the average excess risk estimates to 26 per cent compared to Sudan's 39 per cent with comparable percentage of births born to mothers with no schooling. But, for Sudan, the "true" estimate of excess mortality attenuates almost wholly due to the confounding effect of husbands schooling present in the same multivariate relation. In the case of Yemen, about 6 per cent of higher order births were to mothers with some schooling years; this is a tiny percentage yet the effect of benefit is reflected by the model estimates.

More indirectly and through a socio-economic dynamic, births to mothers whose husbands had some schooling are expected to be in a setting promotive of survival chances. The odds of death are significantly increased by 37 per cent in Sudan, 24 per cent in Yemen, and a narrower 17 per cent in Egypt, respectively, for later births to mothers whose husbands had no schooling.

By a similar dynamic, husbands' occupation in agriculture is more of an indicator of poorer socio-economic familial-settings. Invariably, there was very little evidence of excess risks associated with the survival chances of later births and their fathers' work in agriculture.

Following is the discussion of the results from the Cox model analysis with the addition of three extra variables.

4.4.2 Selective Time-varying Correlates of Higher-order Births Survival to Age 5

In this section, the original relative risks (RR) obtained from the Cox model are discussed - here the three relative additions are the "Period-effects" and the time-varying factors, the occurrence of one "extra" older sibling death after the birth of the index child, and, the status of the subsequent birth. Table 4.4.2 (page 152) presents the analysis of mortality before age five using Cox models on the three samples of births born 0-15 years before the survey.

To account for the changing trends in mortality across cohorts of later births, a "period-effect" variable was added describing three 5-birth-year periods before the survey time. For the period "0-4" years before the survey (or the late 1980s), the average estimates reiterates the positive change observed with first births; mortality risks have reduced on average by 30 per cent in Egypt and Yemen, and yet again with no real change to the situation in the case of the Sudan.

The "extra sibling death" is a time-varying variable applicable only to later births to capture the extra risk triggered by the "new event" of an older sibling's death. This constitutes a rare event occurring to less than three per cent of higher order births for these countries, yet unfolds as much as a three-and-half times excess mortality hazard for later index births in Egypt and Sudan, respectively. In Yemen, the time-varying effect has the same level of high significance but indicates a somewhat lower magnitude of extra risk.

Recalling the time-varying states of the survival status of the subsequent pregnancy: state 0 indicates a state of no subsequent conception as yet; state 1 indicates a state of a subsequent conception; state 2 indicates a state of a subsequent birth and state 3 indicates death of a subsequent birth, respectively, occurring during the first five years of life as exposure time.

Table 4.4.2 : Comparative Relative Risks (RR) of Survival to age 5 (Higher-Order Births)

Correlates	Egypt (1991) N=20252 (%)	Egypt (1991) Cox Model (RR) RR (95 % C.I.)	Sudan (1992/93) N=12532 (%)	Sudan (1992/93) Cox Model RR (95 % C.I.)	Yemen (1991/92) N=19078 (%)	Yemen (1991/92) Cox Model (RR) RR (95 % C.I.)
Sex						
Male	51.3	0.98 (0.9,1.06)	51.6	1.18***(1.06,1.30)	51.7	1.12*** (1.03,1.21)
Female (Ref)	48.7	1.00	48.5	1.00	48.3	1.00
Mothers' age at birth						
< 18 years	2.1	1.33*** (1.07,1.65)	3.0	1.28* (0.98,1.67)	3.4	1.16 (0.96,1.4)
18-19 years	4.7	1.04 (0.87,1.25)	5.1	1.01 (0.79,1.30)	5.8	1.02 (0.87,1.21)
20-24 (Ref)	26.9	1.00	24.7	1.00	25.1	1.00
25-29	29.7	0.88** (0.79,0.99)	27.9	1.01 (0.87,1.17)	26.7	0.94 (0.84,1.05)
30-34	21.8	0.86** (0.75,0.99)	21.5	1.04 (0.87,1.23)	19.5	0.94 (0.83,1.07)
35 +	14.8	1.02 (0.87,1.20)	17.8	1.25** (1.02,1.52)	19.5	0.97 (0.83,1.12)
Previous Birth Interval						
< 18 months	21.0	2.35*** (2.11,2.61)	21.3	1.98***(1.73,2.25)	37.6	2.46*** (2.16,2.79)
18-23 months	17.1	1.45*** (1.28,1.64)	17.0	1.16* (0.99,1.36)	17.8	1.53*** (1.32,1.79)
24-35 months (Ref)	29.7	1.00	33.7	1.00	23.3	1.00
36+ months	32.1	0.65*** (0.57,0.74)	28.0	0.70***(0.59,0.82)	21.3	0.75*** (0.63,0.90)
Birth Order X Previous Deaths						
B2-3 X 0 deaths (Ref)	40.5	1.00	32.7	1.00	30.5	1.00
B4-6 X 0 deaths	21.6	1.04 (0.91,1.19)	26.1	0.91 (0.78,1.07)	23.4	0.79*** (0.69,0.90)
B7+ X 0 deaths	3.6	1.27* (0.99,1.63)	10.0	0.84 (0.66,1.06)	7.5	0.60*** (0.47,0.76)
B2-3 X 1 death	3.0	1.67*** (1.37,2.03)	2.4	1.56***(1.16,2.08)	2.7	1.29** (1.06,1.56)
B4-6 X 1 death	11.9	1.59*** (1.39,1.82)	9.4	1.32***(1.09,1.59)	10.8	1.25*** (1.09,1.43)
B7+ X 1 death	4.7	1.46*** (1.19,1.8)	7.5	1.09 (0.86,1.40)	7.0	1.05 (0.87,1.27)
B4-6 X 2 deaths	4.7	1.76*** (1.48,2.09)	3.2	1.40** (1.08,1.82)	4.6	1.09 (0.91,1.30)
B7+ X 2+ deaths	10.0	1.81*** (1.55,2.13)	8.7	1.30** (1.05,1.62)	13.5	1.27*** (1.09,1.46)
Previous Child Survived to Birth of Index Child						
Yes (Ref)	87.5	1.00	90.2	1.00	87.2	1.00
No	12.5	1.50*** (1.36,1.65)	9.8	1.59***(1.38,1.84)	12.8	1.78*** (1.62,1.96)
Area of residence						
Urban (Ref)	33.1	1.00	33.5	1.00	22.6	1.00
Rural	66.9	1.20*** (1.08,1.33)	66.5	0.97 (0.86,1.1)	77.4	1.04 (0.93,1.17)
Mother attended School						
No	67.8	1.19*** (1.06,1.33)	65.7	1.28***(1.10,1.49)	92.6	1.40*** (1.11,1.76)
Yes (Ref)	32.2	1.00	34.3	1.00	7.4	1.00
Husband attended School						
No	47.6	1.17*** (1.06,1.28)	53.5	1.23*** (1.08,1.4)	74.0	1.17*** (1.04,1.31)
Yes (Ref)	52.4	1.00	46.5	1.00	26.0	1.00
Husband in Agriculture						
No (Ref)	64.1	1.00	61.1	1.00	68.8	1.00
Yes	35.9	1.00 (0.91,1.10)	38.9	1.02 (0.91,1.14)	31.2	1.03 (0.94,1.13)
Years Before the Survey						
"0-4"	34.5	0.70*** (0.62,0.78)	32.9	0.98 (0.86,1.13)	33.4	0.69*** (0.61,0.77)
"5-9" (Ref)	33.7	1.00	37.0	1.00	38.5	1.00
"10-14"	31.8	1.05 (0.96,1.15)	30.1	0.96 (0.85,1.08)	28.1	1.17*** (1.06,1.28)
Extra Sibling Deaths						
None (Ref)	97.9	1.00	97.3	1.00	97.5	1.00
1 Extra death	2.1	3.43*** (2.72,4.33)	2.7	3.57*** (2.8,4.57)	2.5	2.60*** (2.07,3.27)
Status Subsequent Birth						
0 = None (Ref)	60.4	1.00	54.4	1.00	54.3	1.00
1 = Conception	19.8	2.35*** (2.04,2.7)	22.6	1.77***(1.48,2.12)	22.8	1.04 (0.91,1.19)
2 = Birth	18.0	2.46*** (1.93,3.15)	21.2	1.81***(1.41,2.32)	21.0	0.72***(0.58,0.89)
3 = Death	1.8	2.62*** (1.71,4.01)	1.8	3.48***(2.42,5.00)	1.9	1.18 (0.84,1.65)

*** sig. at 0.1%, ** sig. at 5%, * sig. at 10%; *Ref: Reference Group*

To describe the distribution of the time-varying variable at the end of the exposure time, slightly more than half of the higher order birth remains with no subsequent pregnancy taking place, hence employed as the reference state. About one-fifth of higher order births exit the exposure time with a subsequent conception taking place; the average significant excess risk parameter estimate corresponds to a relative risk of 2.35 : 1 in Egypt and 1.77 : 1 in Sudan, (both with p-values < 0.001), respectively, but almost absent in the case of Yemen. Another one-fifth of higher order births exit the exposure time with a subsequent birth taking place; similarly, the excess risks are two-and-a-half times higher in the case of Egypt and close to doubled in the case of Sudan, respectively, but the dramatic and unexplainable reversed influence with 28 per cent lower risk maintains for Yemen. The remaining tiny percentage of later births (less than two per cent) exit the exposure period with a subsequent child's death; these have the highest estimates of *all* previous states. The estimation for Yemen persists with non-changing risk estimates with the death of a subsequent birth in the first five years of life of the index child.

In conclusion, both model-based analyses show slightly higher risks for male higher-order births of death before age five when compared to females, in the cases of Sudan and Yemen. This finding is perhaps largely attributable to more than average under reporting of female deaths. For Egyptian later births the non-significant estimate indicates lower mortality risk for male births which could point toward preferential treatment leading to lower mortality risks; yet the data quality assessment has shown normally behaved sex ratios by surviving status of annual births. When mothers have second and later births before their twentieth birthday, clear excess risks of losing them is evident especially in Egypt. When later births are born to mothers of age 25 and more, their survival chances are evidently promoted in Egypt and Yemen, with Sudan showing little response to that, which could post a question about the quality of mothers' reported age at the time of the survey.

The detrimental effects of short preceding birth intervals is the sharpest and highest communality cross countries; risks are close to trebled when higher order births follow a birth interval of less than 18 months. Inversely, when birth intervals are longer than three years, risks are reduced by at least a third. With the familial history of child losses whenever there is a sibling's loss there is a significant indicator of excess mortality risks for index higher order births. Even when such death events are subsequent to the birth of index births. With respect to every index higher order births in Egypt and Sudan, subsequent pregnancies constitute considerable risk at whatever status they hold. Yet, results remain inconclusive for the Yemeni situation.

Once again, as observed earlier with the analysis of first births, the socio-economic differentials combine differently for each country. In Egypt, rural residence and parental lack of schooling characterise higher births with significant higher risks. In Sudan, later births born to parents with no schooling have at least a one-third increase in mortality risks compared to their counterparts. And in Yemen the strongest and least favourable socio-economic differential in child survival chances is associated with husbands' lack of schooling. Lastly, the estimated changes attributable to the mortality transition under way have been in favour of lower risks for later births born in the most recent period; revealing a sizeable change in the cases of Egypt and Yemen, and almost absent in the case of Sudan.

Lastly, it must be stressed that the discussion of methodological returns has not been overlooked, rather saved for Chapter Six, following the implementation of the multi-level analysis in Chapter Five. In that way, repetition is avoided and better methodological comparisons can be corroborated.

4.5 Summary and Key findings

The premise of this chapter is the multivariate *nature* of correlates of child survival; child survival to age five was investigated using a sub-section of maternity histories from the PAP-CHILD survey in the three settings. Methods of analysis included life-table methods, multivariate logistic models, adjusting for sampling design, and Cox models with time-varying covariates. The multiple comparisons considered whether the dynamics leading to better child survival are common and operate similarity for all three settings.

Life-tables readily summarised failure or estimated death rates aiding a short list of key correlates to be identified for introduction to the multivariate analysis. The period covered in the sub-samples is roughly between the early 1970s to the late 1980s. The life-table figures indicate lower rates of death for the Sudan compared to both Egypt and Yemen at the start of that period. During the period in-between, Egypt leads the group almost halving mortality rates followed by Yemen, for which rates fell by a third. Yet at the end of that period, the rate of mortality decline in the Sudan trails behind Egypt's and levels are stagnant or even on the increase.

The analysis presented here address the question of clustering of deaths within the family in a novel and direct way. Two types of multivariate models were deployed; the first model was a simplified approximation to those used in three of the major comparative analyses carried using data from WFS (Hobcraft, McDonald and Rutstein, 1983, 1984 and 1985). The second model allowed for the incorporation of time-varying associates of extra mortality effects in the family relative to the index child (as recommended by Hobcraft, 1994). Similar results to those identified by this study are supported by comparative studies of survival chances of children born in the five-years period before DHS (Boerma, Sommerfelt, and Rutstein, 1991; Boerma and Bicego, 1992; Bicego and Ahmad, 1996).

For every child, an "event-history" of child losses within the household (e.g. death of siblings older or younger) was created from the live birth history data and incorporating time-varying factors. One of these factors captures events of older sibling deaths after the birth of the index child; these proved to be rare events yet constitute short periods of immediate risk to the index child. Similarly, the second of the time-varying factors represents the status of the subsequent pregnancy through conception / birth / death, which entails extra immediate risks applicable to both first and higher order births.

Daughters in Sudan and Yemen appear to experience lower mortality before age five, but not for Egypt (also observed by Hobcraft (1994)). This is also demonstrated by the data assessment exercise in the cases of Sudan and Yemen, that could be due in part to the under-reporting of female deaths. Adlakha and Suchindran (1985) using YFS (1979) identified a persistent pattern of mortality differentials by sex in Northern Yemen. Further to the findings of Adlakha and Suchindran (1985) of lower early childhood mortality for male births, Timæus, Harris, and Fairbairn (1998), using YDMCHS (1991/92) report clear evidence of systematically greater use of health services by Yemeni male than female children.

Sex differentials in infant and child mortality are found in many societies. Male mortality is normally higher than female mortality through infancy and childhood, apparently due to biological factors, but where the status of males is high relative to females the differential may disappear or be reversed. Eid and Casterline (1988), Makinson (1986) and Ahmed (1990) all noted that such a reversal occurs after infancy in Egypt. Choe et al., (1998) was an investigation using Egypt's DHS-I (1988), which assert that the magnitude of the sex difference depends on the sex composition of older siblings; specifically girls who have older brothers but no sisters have lower mortality rates than those with older sisters. Similar observations were made elsewhere in India (Das Gupta, 1990) and Bangladesh (Muhuri and Preston, 1991). Using the same data set, Timæus, Harris, and Fairbairn (1998) investigated the existence of any regional patterns in sex differentials in the use of certain preventive and curative health services – Egypt showed a weaker pattern of the use of health services favouring male over female children.

The deleterious effects of motherhood in the late teens (18-19) feature in this analysis though these were weaker than expected. In Egypt alone, higher-order births born around the middle maternal age group 25-34, show lower risks of death compared to those born to older mothers and younger mothers. A back drop of the weak association of mothers' age and child survival, in the cases of Sudan and Yemen, is the presence of stronger correlations in the multivariate model. This can perhaps be supported by Zenger's (1993) view that the stronger association observed for immediately adjacent pairs of siblings indicate that familial mortality effects change over time or with maternal age, so that conditions experienced by siblings close in age are more similar than those for siblings born farther apart. One could also question the accuracy of reporting maternal ages at the time of survey, upon which the measure is critically based.

Earlier deaths among the older siblings are generally associated with higher mortality for the index child. One expectation is that excess mortality for the index child would increase with increasing numbers of earlier dead children, which was not always the case in this analysis. These are perhaps proxies tapping on unobservable behavioural practices of childcare in the family unit. In all cases, the clustering of older sibling deaths is associated with a persistent rise of mortality risks, though, with the exception of Egypt, the overall magnitude of this increase rarely exceeds that where the immediately previous child died before the birth of the index child. In the case of Sudan and Yemen, older siblings' mortality indicates moderately increased risks for the index child. Here, there is the possibility that the survival chances of "earlier" births becomes progressively less relevant in periods of rapid change in child survival, both because the past health environment is no longer reflected in the current one and since higher order births inevitably occurred later in time than the lower order births. This view is perhaps more supportable by the phasing of mortality change in Yemen, whilst in the case of Sudan, the same argument will not hold. Furthermore, the phasing of mortality change is well underway in Egypt, yet the differential conveys stronger effects as counts of siblings mortality increase with increasing parity. Also the clustering of death within families could rise steeply from cross-infections (e.g. Measles – see Aaby (1988)) occurring all at once, reducing possible explanatory power for subsequent survival chances in the family (Hobcraft, 1994).

The survival status of the immediately previous child is a critical adjuster/indicator of a child's immediate familial survival-setting. Comparing these results on "earlier" birth effects with those for the preceding birth, the slightly larger value for the latter indicator of death perhaps indicates that proximity in risks plays a part. This result is perhaps supportable by the evidence provided by Hobcraft, McDonald, and Rutstein (1985) that greater excess mortality arose from the correlation of survival chances within families and operated in addition to the impact of the poor spacing.

In the analysis of child survival, controlling for the survival status of the preceding child at the time of birth of the index child reduces the relative risk associated with short intervals with significant effects, but the reductions are generally modest (Boerma and Bicego, 1992). Controlling for the survival status of the previous child did not lead to an increase of the effects of short intervals on mortality when the previous child is alive, and rather shows that the effects of increased intra-familial mortality risks are stronger than are the effects of sibling competition.

It is quite plausible that some of the effects of the length of the preceding birth interval are being captured by the indicator of the survival of the preceding birth, since an early death will usually cause a shorter than average subsequent interval. In all settings, and in spite of Egypt's higher contraceptive use rate, a considerable percentage of births were born less than 18 months apart. This constitutes the highest of risk states, reducing survival chances considerably in the three settings. Short birth intervals are associated with poorer quality births, especially with low birth weight (DaVanzo, Butz, and Habicht, 1983) and prematurity, and the ramification of the poorer maternal recovery time in-between successive births.

One observation concerns the changes in mortality levels with time; to describe the distribution of the time-varying variable at the end of the exposure time, slightly more than half of later births remain with no subsequent pregnancy taking place, hence employed as the reference state. About one-fifth of higher order births exit the exposure time with a subsequent conception taking place; the average significant excess risk parameter estimate corresponds to a relative risk of 2.35 : 1 in Egypt and 1.77 : 1 in Sudan, (both with p-values < 0.001), respectively, but almost absent in the case of Yemen. Another one-fifth of higher order births exit the exposure time with a subsequent birth taking place; similarly, the excess risks are two-and-a-half times higher in the case of Egypt and close to doubled in the case of Sudan, respectively, but the dramatic and unexplainable reversed influence with 28 per cent lower risk maintains for Yemen. The remaining tiny percentage of later births (less than two per cent) exit the exposure period with a subsequent child's death; these have the highest estimates of *all* previous states. The estimation for Yemen persists with non-changing risk estimates with the death of a subsequent birth in the first five years of life of the index child.

Mortality risks dropped by one-third in Egypt and Yemen, comparing the late 1970s and the first half of the 1980s. In Sudan, child mortality has stagnated almost reversing direction, a clear ramification of the country's poor socio-economic and political stability. That alarming finding dovetails with that of Farah and Preston (1982), who showed that mortality in Sudan had not improved anywhere near the pace that had come to be expected as normal in developing countries for the 1955-73 period.

Although most of the socio-economic information collected at the time of the survey is less pertinent to the time of birth of these cohorts, proxies deliver key findings. Extra disadvantage to survival chances entailed by rural residence prevail only in Egypt. An indicator of mothers' schooling was included in all models primarily because it is the socio-economic variable used in almost all other studies of child survival. It has been available to researchers because it is usually fixed before a woman begins childbearing and is easily ascertained in a cross-sectional individuals survey. The comparative advantage of having an educated mother are more evident in Sudan and Egypt than Yemen. Whilst the effect of education on the risk of death is generally significantly negative, it was often a modest one. In the case of Sudan, the weak significance of maternal schooling as a determinant of child's survival could be attributable to the economic power that education gives their husbands. For these mothers, schooling is likely to cease before entry into marriage and motherhood. Hobcraft (1994) suggests that, since maternal education usually is casually prior to such survival outcomes, the gross effect might better capture the role of maternal education. In the case of Egypt, effects of maternal schooling were surprisingly modest. Eid and Casterline (1988) also investigated the association of parental education status and the probability of survival of their children only to find it rather weak. Casterline, Cooksey, and Ismail (1992) demonstrated that in infancy and in early childhood, mortality is strongly associated with region of residence and maternal demographic characteristics, and is weakly associated with parental schooling. Their conclusion could also hold for the same associations in the case of Egypt and may further apply to Yemen.

One observation to make is the lack of a geographical gradient in the multivariate relationships. Since sample stratification was by region or governate of residence, the survey logistic regression deployed was producing estimates of marginal effects already strata-adjusted.

On a few occasions, some of the variables examined had the expected sign, but were not close to being significant. While it would be tempting to believe general result and dismiss these variables, such a conclusion would probably be premature.

So far, analyses presented have handled sub-samples from live-births histories as a random selection of births ignoring hierarchical structures within samples. In the next stage, multilevel models will be used to adjust for the clustering of births born to the same mother and the clustering of mothers / households within clusters. The quality of housing questionnaire added an opportunity to quantify and examine a few contextual characteristics of the geographical cluster distribution – those will be deployed in the multi-level model based analysis of the next chapter.

CHAPTER 5

ANALYSIS OF CHILD SURVIVAL USING MULTI-LEVEL MODELS

5.1 Introduction

In the analysis of the previous chapter, factors affecting child mortality were dealt with what was termed single-level models. Using retrospective maternal histories, the technique of multivariate regression allowed the reassessment of relationships between bio-demographic and socio-demographic characteristics and perceived risk of childhood death, net of confounding effects. Analysis of the type detailed in Chapter Four treats birth histories as independent observations for each child. Yet children belonging to the same mother will tend to be more correlated in survival experience than children belonging to different mothers or households. The term *correlated* is used collectively to relate to biological, demographic and socio-economic attributes shared by those siblings. Perhaps least discussed are biological disadvantages, which arise when some mothers experience more problems with pregnancy than others do (such as premature delivery, intrauterine growth retardation), which are more likely to be repeated from one pregnancy to the other. What has been previously termed an unobserved household effect or correlation among siblings' mortality risks has been interpreted as the upper bound of shared genetic factors (Guo, 1993).

The structural clustering of the unit of analysis results from the sampling design – that is following the household survey, the individual survey revisits a sample of mothers in reproductive ages to collect information on their reproductive history and behaviour. Although the problem of correlated observation emerges in part because of the type of sampling scheme used, the effects of unobserved cluster and household factors on child outcomes are present regardless of the study design (Goldstein, 1995: p.110).

These correlations will have two implications. Hobcraft, McDonald, and Rutstein (1983) noted that the estimated standard errors would be too small. This may lead to narrower confidence intervals, hence exaggerating the significance of parameter estimates of some key correlates. Also, under the assumption that observations or births are independent, there should be a random pattern to the occurrence of deaths in the data set. Instead, some "clustering" of mortality in certain families or household will characterise certain settings. This would be due in part to children sharing the same observed maternal and environmental risks. Hence, and with respect to child losses, data sets will contain more variability than allowed for by conventional marginal models.

The analysis of this chapter uses a multi-level logistic model to identify how sizeable and how significant are the effects of unmeasured factors and to minimise any sample design effects not accounted for previously. Once identified, the aim is to discover how much the observed variables at pertinent levels of the hierarchy reduce the effects of "unmeasured" effects. And, if residual effects remain, can models further identify where the unmeasured factors are under-pinning further reductions in child mortality.

The methodological adjustment in using a hierarchical multi-level model is in the introduction of a quantity or a "frailty" factor for each level to represent the effects of a multitude of unmeasured or unmeasurable factors. For the purpose of this work, the first level of clustering is readily identifiable as the clustering of children within households, followed by the clustering of households within clusters. A cluster is a sample of about 20 to 30 households on average from a collection of households. Usually a geographical cluster shares environmental conditions as well as common services provision, such as the main water supply, sanitation, provision of electricity and health services. Probably this level is questionable as a natural level of clustering (vis-à-vis village and community distribution), but previous work has shown that if a level of design clustering is ignored, this could result in a substantial overstatement of the true household-effect. Sastry (1997) also noted that when he used cluster rather than municipalities which were larger and more diverse than sampling clusters, it lead to no substantive differences in the results.

The analysis to follow is applied only to singleton births born in the period 5-15 years prior to the survey. The same array of bio-demographic, socio-economic and cluster "contextual" characteristics, used in Chapter Four, carry-across to this analysis as explanatory variables of under-five mortality.

As previously reviewed in Chapter Three, different methods have been devised to introduce hierarchical correlations to model-based analysis. The method chosen for this analysis is that deployed by MLn / MLwiN© binomial multi-level model, which applies an exchangeable or equal correlation structure between members of same level unit. One limitation to using multi-level models, is that they can not readily be treated as marginal models (i.e. summarising all the variations within the population through a simplistic model relation). An added complexity is that the with MLM, the assumption is that correlation amongst siblings is fixed or a constant. Intuitively, adjacent births are expected be more correlated as compared to further apart births – to investigate this issue, amongst others, Section 5.2 re-visits concepts and methods of multilevel models. Sections 5.3, 5.4 and 5.5 present results from country-specific multi-level analysis, with each analysis divided for first births (with no household clustering effects) and higher-order births, respectively. In Section 5.6 key findings are summarised and the implications of the use and non-use of multi-level adjusting analysis are discussed.

5.2 Revisiting Concepts and Methods of Multi-level Models

Exactly what is meant by "siblings' correlation in mortality"? A simple answer to the question is that closer birth orders tend to have closer relations in outcomes than those farther apart. One way to test this is by relating the survival status of an index child to that of the previous siblings through a lag or a step by a series of relations for the three countries (shown in Table 5.2.1 below) . Included are lags up to birth order 12, given that cross countries birth histories show a substantial number of births per woman. Table 5.2.1 illustrates the percentage column of all births j that had a j-k older sibling who died before age five, and the corresponding pair-wise odds ratios for values of the lag k ranging from 1 to 12 by country. This examination elucidates the familial correlation structure in the three settings, since the random effects logistic model assumes equal correlation between all children. Adopting the same approach used by Zenger (1993), pair-wise odd ratios for siblings are computed to give an approximate estimate of the association between pairs of siblings. These were obtained using a series of logistic regressions where the survival status to age five of the index child j is predicted using that of child j-k for different values of k. As only children of order k+1 can be included in the analysis, the sample becomes more restricted as k increases.

Common to all three countries, the association in the risk of death before age five is very strong for adjacent siblings, and although this weakens as k increases, there is still evidence of households association between siblings. The decline in the association in the survival chances of siblings at increasing lags is intuitively sensible as the period between births at greater lags is also greater. Yet associations should trail-off (clearly demonstrated in the situation of Sudan and Yemen) as a function of changes over time in the family circumstances and new facilities and technologies affecting child survival that may have become available (e.g. immunisation, new hospitals or health centres). A slight "kick-up" effect of the odds ratios can be observed in the case of Egypt (at lags, k *10* and *11*) which is due to a selection effect (representing less than 1 per cent of births).

Table 5.2.1 Pair-wise Odds Ratios (j,j-k) relating odds of death before age 5 for index child j to the odds of infant death of (j-k)th child **by country.**

	Egypt		Sudan		Yemen	
lag, k	%	OR	%	OR	%	OR
1	10.0	2.04***	11.5	2.34***	11.5	2.24***
2	9.9	2.00***	13.6	2.17***	12.4	1.76***
3	8.1	1.45***	11.6	1.38**	10.6	1.35***
4	6.6	1.51***	9.7	1.26**	8.7	1.17**
5	5.5	1.47***	7.9	1.17	6.6	1.19**
6	3.8	1.35**	5.9	1.46**	4.8	1.23**
7	2.7	1.50***	4.3	1.24	3.3	1.19
8	1.7	1.32**	2.9	1.59**	2.1	1.37**
9	1.1	1.56**	1.8	1.39	1.2	1.24
10	0.7	2.14***	1.1	1.57	0.6	1.14
11	0.4	2.17**	0.5	1.89	0.2	1.22
12	0.2	0.93	0.3	1.47	0.1	0.64

*** Sig. 0.001, ** Sig. 0.05, * Sig. 0.1

The highest correlation exists between adjacent births, showing essentially constant "family level" risk environment beyond lag two. Tighter correlations with lags 1 and 2 are suggestive of immediate and timely risks between the siblings involved such as cross-contamination, for example, with measles infection. It is important to note that these correlations are bivariate in nature, which may disappear when multivariate correlations with the effect of immediately previous sibling survival and that of the length of the preceding birth interval are controlled for.

Table 5.2.2 Odds Ratios relating odds of death before age 5 for the index child to the count of under-five deaths in the same cluster, **by country.**

	Egypt (clusters=460)			Sudan (clusters=230)			Yemen (clusters=257)		
	Grouped Cluster Count of Death	%	Odds Ratio (OR)	Grouped Cluster Count of Death	%	Odds Ratio (OR)	Grouped Cluster Count of Death	%	Odds Ratio (OR)
	0-9	28.2	1.0	0-9	23.0	1.0	0-13	25.8	1.0
	10-15	24.1	2.14***	10-14	25.9	1.31***	14-20	27.0	1.69***
	16-22	23.2	2.86***	15-20	25.2	1.77***	21-28	22.1	2.27***
	23+	24.6	3.96***	21+	25.9	2.22***	29+	25.1	3.00***
N=	16,589	100.0		10,144	100.0		15,094	100.0	
Mean=	36.1			44.1			58.7		
S.D.=	14.3			20.4			21.4		

*** Sig. 0.001

Mean = Mean Number of Births per cluster;

S.D. = Standard Deviation of the Mean Number of Births per cluster.

Similarly, births residing in the same geographical cluster are expected to be more correlated in their survival chances when compared to children belonging to separate clusters. One simplistic investigation of that comes in relating the survival status of each birth to a count of children's deaths before age five in the same cluster. Shown by Table 5.2.2, the monotonic, yet non-linear, increase in the correlation of child survival to age five with counts of children deaths before age five in the same cluster.

To introduce these correlations in the multilevel logistic model, one random effect is assigned for each selected level of clustering, that is a random effect due to a cluster-effect and another due to a household-effect. The analysis will extend the representation of the cluster unmeasured effects with respect to a collective feature for each country e.g. clusters within the same governate or region. That requires more than one variance-component estimate to describe the cluster-effect. For example, Egypt has five governates; in the case of Sudan there are six governates and in the case of Yemen, there are two broad regions. An ideal and quite experimental situation, would be to split the household-effects to correspond to their respective segregated cluster-effects.

One extra issue deals with the residual variance e_{ijk} at level 1 (or the child level). In this analysis, the probability in the population of the outcome is π_{ijk}, then assuming there are only two possible outcomes, the population variance is π_{ijk} $(1-\pi_{ijk})$. With this analysis, the model is unlikely to completely account for all the differences between clusters and households. This can lower the estimated variance of e_{ijk}, what is termed *under-dispersion* (i.e. $\sigma^2_e < \pi_{ijk}(1-\pi_{ijk})$). This is because in the real-world problems there are likely to be characteristics of the clusters and households that increase the intra-cluster and intra-household correlation and yet have not been accurately measured or not incorporated into the model (Wright, 1997). One commonly followed formula to check for extra-binomial variation is to represent the variance of the residuals as follows:

$$\mathbf{Var(e_{ijk}) = \sigma^2_e = \phi\ \pi_{ijk}(1-\pi_{ijk})}$$

and to determine whether ϕ is significantly different from 1.

More generally, when the average observed probability is very small, or there is sparsity at one or more of the lower levels (for example when only two children are considered by the analysis for a particular set of households), under-dispersion, or lack of convergence, can occur. This is because especially with sparse data structures there will often be no variation in responses for some level 3 and level 2 units and this can hamper estimation (Goldstein, 1995, p.101; Wright, 1997). Extra-binomial variation is usually taken as a sign that a level of the data structure has been left out and /or further explanatory variables are necessary for the model. Yet, if sufficient numbers of level 2 units (or households), where there will be adequate response heterogeneity, satisfactory estimates can be obtained even where probabilities are very small (or large) (Goldstein, 1995:p.101). There was some evidence of under-dispersion at first for the null model with no covariates in Sudan and Egypt. But in the more elaborate models, convergence was smoother due to the increased explanatory power[7]. Goldstein (1995) further advises that further research is needed to evaluate the reliability of modelling with regard to sparsity at level 1 for binomial models especially.

The estimation technique used by the modelling packages is iterative i.e. starts with one value for the performance of quasi-likelihood estimation, follows some algorithm until small changes are found for the current estimates. One method of the type outlined previously is marginal quasi-likelihood (MQL) and a first-order Taylor expansion during the approximation process. In accord with the findings of Breslow

[7] Results from a simulation carried out for both Sudan and Egypt, show that reappearance of under-dispersion with the final model specification is a characteristic of the data structure – this in turn is a product of sparsity. If it had disappeared, it would imply that the model, in some way, was not perfect.

and Clayton (1993), and, Rodríguez and Goldman (1995), the MQL macros tend to produce downwardly biased estimates of the fixed parameters when substantial random effects were present. Breslow and Clayton (1993) proposed using penalised quasi-likelihood (PQL), also called predictive-quasi-likelihood, instead of MQL which takes into account the estimates for both the fixed and random parameters during the iterations of the basic algorithm used in MLn / MLwiN. Further, using a second-order Taylor expansion in the algorithm generally improves the estimates compared with a first-order expansion (Goldstein, 1995).

No one strategy is clearly outlined to achieve efficient convergence. But the following strategy proved to be reliable -- model estimation starts-off with MQL first-order Taylor expansion until convergence is reached, followed by the PQL first-order and then the second-order expansion with PQL (which in most cases did converge) for final estimation. For the iteration process the restricted iterative generalised least squares (RIGLS; Goldstein, 1989) procedure was used since it produces unbiased estimates particularly with small sample sizes.

For each country, the analysis splits the birth history into first and higher-order births. Obviously, one first birth will be contributed by each household, which implies the disappearance of one level of the hierarchy. In analysing first births, only two levels will hence apply; at level 1, a number of first births within each level 2, cluster.

Initially the null model, that is the model with no explanatory variables, the variance-component for the random cluster and household effects are estimated. From these the "intra-cluster" and "intra-household" correlation coefficients based on the formula given shown in Chapter Three (Section 3.4.6, p.123) are estimated. Explanatory variables are then added sequentially to the models to assess the changes to the random-effect estimates induced by including more explanatory variables. Ideally, one expects reductions in the amount of "intra-cluster" and intra-household" correlation with the adjustment for influential explanatory variables at each level.

The multilevel logistic model yields parameter estimates for the fixed part together with their standard errors. These are adequate for hypothesis testing, or confidence interval construction, separately for each parameter using Wald statistic. When testing the significance of the random parameters in the multilevel logistic model, the likelihood statistic is typically very approximate and the Wald test yields better inference (Goldstein, 1995, chapter 7). Though not extensively studied for binary outcomes, another test for the random parameters was proposed by Commenges et al. (1994). Based on the so-called score principle, this is a test for the null hypothesis that there is no random intercept, while controlling for the fixed effects of the explanatory variables (Snijders and Bosker, 1999, p.220). For normal distributions the comparative power performance of the score test is studied in Berkhof and Snijders (2001). Since "robust" standard errors are provided by MLwiN, presented in this chapter are the results of using the Wald statistic for testing the random parameters. Not shown here, random parameters testing was also carried-out with the score principle test, which showed little to no inferential differences between the two methods.

Finally, the resultant multivariate multi-level model estimates will be further used to assess implications of predicted probabilities for survival. The results of the logistic regression are summarised in tables, which identify predictor variables that have a significant (p-value < 0.05) net effect on the predicted probabilities of death before age five.

5.3 Egypt

The data set for the Egyptian PAP-CHILD survey is the largest of all three countries considering the size of the national population covered. The multi-level summary shows 460 independent clusters resulting in a livebirth history of 40,384 births. The sample chosen includes 4,827 households with 16,589 births born in the period 5 to 15 years before the survey.

Fig. 5.3.1 Distribution of the Multi-level Design for the Sample of Births, **EMCHS (1991).**

Region	No. of Clusters	No. of Households	No. of Births	Mean No. of Births / House-hold (S.D.)	Median no. of Births / House-hold (IQR)
Urban Governates	104	984	2,566	2.12 (1.16)	2 (1,3)
Urban Lower	58	608	1,706	2.34 (1.28)	2 (1,3)
Rural Lower	136	1,521	5,836	2.87 (1.47)	2 (1,3)
Urban Upper	54	529	1,627	2.53 (1.35)	2 (1,3)
Rural Upper	108	1,185	4,854	3.06 (1.58)	3 (2,4)
Total	460	4,827	16,589	2.68 (1.45)	2 (2,4)

In Figure 5.3, the regional distribution shows Rural Egypt on average with a higher number of births contributed per unit of level 2 or per household. Also the clusters distribution helps identify Rural Egypt further with the larger contribution of residential clusters in both sub-samples. The interpretation to follow are of the final multivariate model obtained, indexed as **Model A3** (mainly the results of the sequential addition of three scores of explanatory variables; those specific to births, households and clusters, respectively). **Model S3** is included to reaffirm the exact correspondence in the model estimation when splitting the variance-components at the cluster level to the model with a single variance component estimate.

5.3.1 *Mortality of First Births*

Results obtained from modelling under-5 mortality are shown by Table 5.3.1. (in the following page). Starting with the child's gender, the model detects some excess risk for male first births, but the estimate remains insignificant. Almost one-fifth of first births are to mothers aged less than 18 years at the time of birth. Index first births born to these young mothers significantly show at least a two-fifth increase in the risk of death before age five compared to those born to mothers aged 20-24. Conversely, the odds of death before age five are significantly reduced by two-fifth when mothers' age at first birth increases to 25-29. Considering the socio-economic correlates, Model A3 shows the chances of death before age five increase by 37 per cent for first births in rural residence or when their mothers had no schooling. About one in six first births belong to residential clusters with "Pit / Latrine" sanitation; those could face as much as a two-third increased risk of death before age five compared to other first births in clusters with "Toilet / Shared" sanitation.

A dichotomous control, labelled "Years before the Survey", defines two cohorts, those born "5-9" and "10-14" years before the survey, respectively. It was added to capture unmeasured effects of change in risk hazards over time, and indicates change is towards lower risks for the more recent period.

Considering the random-part of the multi-level logistic model, the variance-component for the random-cluster effect progressively diminishes in value and significance with the addition of fixed effects resulting in a minimal "intra-cluster" correlation coefficient ρ_v=0.021. Once the variance-component is split by region, the correlation sinks almost wholly into the Upper Egypt regions variance components – but maintains statistical insignificance. Furthermore, in model *S3,* there was no evidence that the regional cluster-variance components taken jointly are different from zero ($\chi^2_{(5)}$=2.933 , p-value=0.7103).

Table 5.3.1 Egypt Differentials of Mortality before Age 5 for First Births

Multi-level Model Correlates	N=3326	A0 (Null)	A3 MLOR (95% C.I.)	S0 (Null)	S3 MLOR (95% C.I.)
Sex	**(%)**				
Male	52.7		1.16 (0.93,1.43)		1.15 (0.92,1.42)
Female (Ref)	47.3		1.00		1.00
Maternal age at birth					
< 18 yrs	22.0		1.43*** (1.09,1.87)		1.42** (1.08,1.86)
18-19	20.5		0.88 (0.65,1.19)		0.87 (0.64,1.18)
20-24 (Ref)	37.6		1.00		1.00
25-29	15.7		0.60** (0.40,0.9)		0.60** (0.40,0.91)
30-34	3.2		1.21 (0.63,2.32)		1.23 (0.64,2.37)
35 +	1.0		1.10 (0.31,3.89)		1.15 (0.32,4.06)
Area					
Urban (Ref)	39.5		1.00		1.00
Rural	60.5		1.37** (1.01,1.85)		1.47** (1.08,2.00)
Mother attended School					
No	54.7		1.37** (1.04,1.82)		1.37** (1.03,1.81)
Yes (Ref)	45.3		1.00		1.00
Husband attended School					
No	36.0		1.14 (0.89,1.46)		1.13 (0.88,1.46)
Yes (Ref)	64.0		1.00		1.00
Husband in Agriculture					
No (Ref)	28.0		1.00		1.00
Yes	72.0		1.02 (0.79,1.33)		1.03 (0.79,1.33)
Years before the Survey					
"5-9" (Ref)	50.6		1.00		1.00
"10-15"	49.4		1.19 (0.96,1.48)		1.20 (0.96,1.48)
Clusters' Utility					
Electricity (Ref)	96.8		1.00		1.00
Kerosene	3.2		0.87 (0.48,1.60)		0.88 (0.49,1.60)
Clusters' Sanitation					
Toilet/Shared (Ref)	75.2		1.00		1.00
Pit/Latrine	15.1		1.71*** (1.29,2.25)		1.63*** 1.23,2.17)
Open-Air/Other	9.7		1.12 (0.78,1.61)		1.14 (0.79,1.64)
Clusters' Water Supply					
Government/Piped (Ref)	80.7		1.00		1.00
Well/Pumped	19.3		1.25 (0.96,1.64)		1.27* (0.97,1.67)
Cluster-effect	σ_v^2 (s.e.)	0.32*** (0.11)	0.09 (0.08)		
	ρ_v	0.089	0.021		
Cluster-effect (Split)					
Urban Govern.	σ_{v1}^2 (s.e.)			0.0 (0.0)	0.0 (0.0)
	ρ_{v1}			0.000	0.000
Urban Lower	σ_{v2}^2 (s.e.)			0.0 (0.0)	0.0 (0.0)
	ρ_{v2}			0.000	0.000
Rural Lower	σ_{v3}^2 (s.e.)			0.31* (0.19)	0.03 (0.12)
	ρ_{v3}			0.086	0.009
Urban Upper	σ_{v4}^2 (s.e.)			0.43 (0.41)	0.67 (0.53)
	ρ_{v4}			0.116	0.169
Rural Lower	σ_{v5}^2 (s.e.)			0.72*** (0.26)	0.10 (0.13)
	ρ_{v5}			0.180	0.029

***=sig. (0.001) , **=sig. (0.05), *=sig. (0.1)

In summary, first births in Egypt remain at higher risk of death before reaching age five when they are born to very young mothers. They appear to benefit moderately when born to mothers with some schooling, with their survival chances almost unimproved when their fathers had some schooling or worked in a non-agriculture-related occupation. Rural residence in Egypt poses higher risk factors than urban areas for first births; this is further exasperated when clusters lack proper planned sanitation and a piped water supply.

5.3.2 *Mortality of Higher-Ordered Births*

With later births, an intermediate level of random effects is introduced at the household level, and a formidable number of births was available both at the household and child level. For ease of reference, the modelling of mortality before age five are illustrated by Tables 5.3.2A (page 171) and 5.3.2B (page 173), respectively.

Compared to a maternal age of birth of 20-24 years, later births to mothers aged less than 18 years at the time of births are rare (less than 3 per cent). The multivariate relations picks-up as much as a 43 per cent significant increase in the risk of death before age five for a later birth born to very young mothers. The protective effects associated with the middle maternal ages are signalled beyond age 25 years but holds statistical significance only for 30-34 years when the risks of death before age five for index later births could decrease by a fifth.

A stronger differential is that of the length of the preceding birth interval, where one-fifth of later births follow a preceding birth interval of under 18 months. Compared to births following an interval of 24-35 months, the odds of death before age five are close to trebled for later births following short preceding birth intervals. That estimate of extra risk is nearly halved when later births followed an increased preceding birth interval of 18-24 months, which is the case with one-sixth of births in this sub-sample. Compared to the baseline interval of 24-35 months, the protective effect of longer birth intervals are further demonstrated when the preceding birth interval extends to 36 and more months. For births following a birth interval of three years, the odds of death before age five could be reduced by approximately two-fifths of that of the baseline group.

The survival of the preceding child is quite deterministic of the survival chance of index later births. Excessive risk of death before age five are close to two-fifth when the preceding child dies before the birth of the index later births.

Table 5.3.2A Egypt Differentials of Mortality before Age 5 for Higher-Order Births ***(Fixed-effects)***

Multi-level Model Correlates	**N=13263 (%)**	**A3 MLOR (95% C.I.)**	**S3 MLOR (95% C.I.)**
Sex			
Male	51.2	0.95 (0.85,1.05)	0.95 (0.85,1.05)
Female (Ref)	48.8	1.00	1.00
Maternal age at birth			
< 18 yrs	2.7	1.43** (1.08,1.89)	1.43** (1.08,1.89)
18-19	5.1	1.04 (0.83,1.32)	1.05 (0.83,1.33)
20-24 (Ref)	27.0	1.00	1.00
25-29	29.7	0.89 (0.77,1.03)	0.89 (0.77,1.03)
30-34	21.4	0.80** (0.67,0.96)	0.80** (0.67,0.96)
35 +	14.0	0.90 (0.72,1.12)	0.89 (0.72,1.11)
Previous Birth Interval			
< 18 month	24.0	2.81*** (2.45,3.22)	2.79*** (2.43,3.20)
18-23 month	17.4	1.49*** (1.27,1.74)	1.49*** (1.27,1.74)
24-35 month (Ref)	28.7	1.00	1.00
36+ month	29.8	0.56*** (0.47,0.67)	0.56*** (0.47,0.66)
Previous Child Survived to Birth of Index Child			
Yes (Ref)	85.9	1.00	1.00
No	14.1	1.39*** (1.21,1.58)	1.38*** (1.21,1.58)
Birth Order X Previous Deaths			
B2-3 X 0 death (Ref)	39.8	1.00	1.00
B4-6 X 0 death	20.9	1.07 (0.9,1.27)	1.08 (0.91,1.28)
B7+ X 0 death	3.3	1.57*** (1.13,2.17)	1.57*** (1.13,2.18)
B2-3 X 1 death	3.4	1.82*** (1.41,2.36)	1.82*** (1.41,2.36)
B4-6 X 1 death	12.0	1.76*** (1.48,2.10)	1.77*** (1.48,2.11)
B7+ X 1 death	4.6	1.56*** (1.17,2.06)	1.57*** (1.19,2.08)
B4-6 X 2+ deaths	5.4	1.96*** (1.56,2.46)	1.97*** (1.57,2.47)
B7+ X 2+ deaths	10.6	1.87*** (1.51,2.32)	1.88*** (1.52,2.33)
Area			
Urban (Ref)	34.2	1.00	1.00
Rural	65.9	1.22** (1.03,1.43)	1.24** (1.05,1.45)
Mother attended School			
No	69.5	1.24*** (1.08,1.44)	1.25*** (1.08,1.45)
Yes (Ref)	30.5	1.00	1.00
Husband attended School			
No	50.0	1.18*** (1.04,1.34)	1.17** (1.03,1.32)
Yes (Ref)	50.0	1.00	1.00
Husband in Agriculture			
No (Ref)	63.7	0.97 (0.86,1.11)	0.97 (0.85,1.1)
Yes	36.3	1.00	1.00
Years before the Survey			
"5-9" (Ref)	51.4	1.00	1.00
"10-15"	48.6	1.10* (0.99,1.23)	1.11* (0.99,1.23)
Clusters' Utility			
Electricity (Ref)	96.6	1.00	1.00
Kerosene	3.4	0.97 (0.66,1.43)	0.95 (0.66,1.35)
Clusters' Sanitation			
Toilet (Ref)	71.6	1.00	1.00
Pit/Latrine	17.2	1.29*** (1.09,1.53)	1.28*** (1.08,1.51)
Open-Air/Other	11.3	1.08 (0.88,1.33)	1.06 (0.86,1.31)
Clusters' Water Supply			
Gover-Piped (Ref)	79.0	1.00	1.00
Well/Pumped	21.0	1.03 (0.87,1.21)	1.04 (0.89,1.21)
	100.0		

***=sig. (0.001) , **=sig. (0.05), *=sig. (0.1)

The second associate of siblings mortality is the interaction terms of previous death counts of older siblings with the parity group of index later births; the result is even more striking. The baseline group is chosen as second or third births with no older sibling deaths (which were about two-fifths of later births). Where there has been no counts of older sibling death, the expected typical effect is that of "higher disadvantage with higher parity" to operate. This is demonstrated by the increased risk of 57 per cent of death before age five for seven and higher order births with no counts of older siblings mortality. Gradually the risk estimates increase when there is a count of 1 older sibling death with a two-thirds increase in risks of deaths before age five for birth order group 4-6, and slightly more than half increase almost maintains for birth order group seven and higher. Bearing in mind that model A3 (or S3) considerably adjusts for the correlation structures, the lower risk estimates of the latter probably describe the trailing correlation in survival chances of more recent births to those of their older siblings. The incidence of two or more deaths of older sibling leaves seventh and higher order births slightly worse than before and similarly exacerbates the extra risk situation to the smaller percentage parity group 4-6 with close to a two-fold increase in the risk of death before age five.

Correlations with socio-economic factors are reiterated from earlier findings with first births. Rural residence, once more, ensues increases of about one-fifth excess risk for higher births compared to those living in urban areas. With parental schooling, births to mothers with some schooling are slightly worse-off than those whose mothers had some schooling, with a significant one-fifth increase in mortality risks before age five. In this case, the beneficial effects of husbands schooling are shown by an estimate of one-fifth excess risk in mortality for later births to mothers whose husbands had no schooling. Once more, an "adjustor" is introduced to control for any period-changes in the levels of mortality, which shows moderate changes to lower mortality between the late 1970s and the early 1980s.

Turning to the cluster contextual characteristics, the risk of death before age five is increased by about 29 per cent for later births belonging to clusters with "Pit / Latrine" sanitation compared to those in clusters with "Toilet / Shared" sanitation.

Turning to the random-effects, results are summarised in Table 5.3.2B (next page). Model A0, or the null model, initially identifies significant and substantial random-effects at the cluster and household level. Table 5.3.2B should be considered as a continuation of the models presented in Table 5.3.2A, to present elaborately the random-effect estimates obtained. By reference to Table 5.3.2B, two types of entries are examined, estimates of variance components and standard errors, denoted by σ^2 (s.e.), and intra-level correlation coefficients, denoted by ρ. To remind the reader, these correlation coefficients lie between zero and 1. For example, a considerable "intra-household" correlation will indicate household-family environments are more heterogeneous than expected if clustering was ignored and hence a child's survival chance are affected by household-specific unmeasured factors. Otherwise, if the variance-components estimates behind these correlations are small and insignificant then a child's particular membership in any one household (in any one cluster) should have little if no effect on his/her survival chances.

Table 5.3.2B Egypt Differentials of Mortality before Age 5 for Higher-Order Births

Random-effects	N=13263	A0 (Null)	A3	S0 (Null)	S3
Cluster-effect	$\sigma_v{}^2$ (s.e.)	0.29*** (0.05)	0.12*** (0.03)		
	ρ_v	0.065	0.035		
Household-effect	$\sigma_u{}^2$ (s.e.)	0.85*** (0.10)	0.01 (0.06)		
	ρ_u	0.257	0.038		
Cluster-effect (Split)					
Urban Gover	$\sigma_{v1}{}^2$ (s.e.)			0.56*** (0.21)	0.28** (0.14)
Urban Lower	$\sigma_{v2}{}^2$ (s.e.)			0.36* (0.21)	0.11 (0.12)
Rural Lower	$\sigma_{v3}{}^2$ (s.e.)			0.09 (0.06)	0.04 (0.04)
Urban Upper	$\sigma_{v4}{}^2$ (s.e.)			0.06 (0.12)	0.08 (0.10)
Rural Upper	$\sigma_{v5}{}^2$ (s.e.)			0.48*** (0.12)	0.16*** (0.05)
Household-effect	$\sigma_u{}^2$ (s.e.)			0.83*** (0.10)	0.02 (0.06)
Urban Gover	ρ_{v1}			0.120	0.078
Household	ρ_u			0.297	0.084
Urban Lower	ρ_{v2}			0.080	0.032
Household	ρ_u			0.266	0.038
Rural Lower	ρ_{v3}			0.021	0.012
Household	ρ_u			0.218	0.018
Urban Upper	ρ_{v4}			0.014	0.024
Household	ρ_u			0.213	0.029
Rural Upper	ρ_{v5}			0.104	0.052
Household	ρ_u			0.285	0.052

***=sig. (0.001) , **=sig. (0.05), *=sig. (0.1)

In the final multivariate model (A3), the household variance component diminishes to zero specifically when controls of older siblings mortality were introduced. The resultant cluster-effect variance component has a small and significant value with an "intra-cluster" correlation coefficient ρ_v= 0.035.

Also included in Table 5.3.2A, model (S3) is based on splitting the cluster-variance component into five regional estimates; the Urban Governates (Cairo & Alexandria) and Rural Upper Governate emerge with the two sizeable and significant unexplained components, having "intra-cluster" correlations ρ_{v1}= 0.084 and ρ_{v5}= 0.052 respectively. To remind the reader, this is an interesting feature of the analysis since the heterogeneity expected for the Urban Governates may not be readily similar to that of Rural Upper Governates. This is probably suggestive of "true" heterogeneity in socio-economic and environmental conditions "within" both regions, both densely populated, with varying levels of access to population services. For the random coefficients in model ***S3***, one hypothesis to test whether the regional cluster-variance components taken jointly are zero, produces highly significant evidence of inequality ($\chi^2_{(5)}$=16.3 , p-value=0.006).

To summarise, the survival chances for higher-order births in Egypt stand to benefit from lengthier birth intervals and keeping to lower parity births, both conditions enhanced by better rates of contraception. One striking result is in how the controls for the familial history of mortality almost fully explained any household-effects (unmeasureable by the observed covariates). As with first births, higher-order births appear to benefit moderately when born to mothers with some schooling, with their survival chances slightly improved when their fathers had some schooling or worked in a non-agricultural occupations. Rural residence in Egypt holds higher risks compared to urban residence for *all* births, and so is the case with localities lacking "Toilet" sanitation and a piped water supply. Recent improvements captured by the period-control are perhaps capturing benefits of extended programmes of maternal and child health care especially for the post-neonatal period rather than the post-infancy period, which is affected more by mothers and household resources.

5.4 The Sudan

Using the household-survey, the Sudan PAP-CHILD survey continued to re-sample 230 clusters for the women's (and hence birth histories) survey, with a total livebirth history of 22,890 births. Of those, the sub-sample chosen includes 3,211 household units with 10,144 births born 5 to 15 years before the survey date.

Fig. 5.4.1 Distribution of the Multi-level Design for the Sample of Births, SMCH (1992/93).

Governates	No. of Clusters	No. of Household	No. of Births	Mean no. of Births / Household (S.D.)	Median no. of Births / Household (IQR)
Khartoum	48	658	1,890	2.87 (1.49)	3 (2,4)
Eastern	35	390	1,238	3.17 (1.74)	3 (2,4)
Central	59	909	2,928	3.28 (1.66)	3 (2,4)
Darfur	41	559	1,818	3.25 (1.64)	3 (2,4)
Kordofan	34	505	1,676	3.32 (1.69)	3 (2,4)
Northern	13	190	544	2.86 (1.50)	3 (2,4)
Total	230	3,211	10,144	3.16 (1.64)	3 (2,4)

In Figure 5.4 , the regional distribution shows the highest contribution of births from the Central governate, which also has the highest average in number of births per household. The Northern governate contributes the lesser number of births as well as the smallest average number of births per household. With the exception of the Northern governate, governates' cluster numbers are in excess of 30 clusters. The interpretations to follow are concerned with the final multivariate model obtained, indexed as Model A3 (and S3) with three types of regressors.

5.4.1 *Mortality of First Births*

The analysis of first births mortality before age five is shown in Table 5.4.1 (page 176). Of the two bio-demographic differentials added in model A3 (sex and maternal age at birth) only sex shows a significant effect. Male first births carry close to a two-fifth higher risk of mortality before age five compared to female births, especially after the first year of life. Such an estimate is perhaps more than average given what is recognised as an innate biological characteristic of male births, and suggests under-reporting of dead female firstborns.

The U-shaped relation of extra risks of death with very young and older maternal age at first birth is visible but remains insignificant in the multivariate relation.

Table 5.4.1 Sudan Differentials of Mortality before Age 5 for First Births

Multi-level Model Correlates		N=1646	A0 (Null)	A3 MLOR (95% C.I.)	S0 (Null)	S3 MLOR (95% C.I.)
Sex		**(%)**				
Male		52.9		1.38** (1.02,1.88)		1.40** (1.03,1.91)
Female	(Ref)	47.1		1.00		1.00
Maternal age at birth						
< 18 yrs		33.2		1.28 (0.88,1.85)		1.28 (0.88,1.86)
18-19		19.8		1.13 (0.74,1.74)		1.13 (0.73,1.75)
20-24	(Ref)	32.2		1.00		1.00
25-29		11.2		0.77 (0.43,1.38)		0.77 (0.43,1.38)
30-34		3.0		0.52 (0.15,1.77)		0.52 (0.15,1.77)
35 +		0.6		0.82 (0.10,6.88)		0.83 (0.10,6.97)
Area						
Urban	(Ref)	36.5		1.00		1.00
Rural		63.5		1.21 (0.80,1.83)		1.22 (0.80,1.86)
Mother attended School						
No		51.3		0.94 (0.63,1.39)		0.95 (0.64,1.42)
Yes	(Ref)	48.7		1.00		1.00
Husband attended School						
No		41.3		2.06*** (1.40,3.03)		2.07*** (1.40,3.06)
Yes (Ref)		58.7		1.00		1.00
Husband in Agriculture						
No	(Ref)	32.6		1.00		1.00
Yes		67.4		0.67** (0.46,0.98)		0.67** (0.45,0.98)
Years before the Survey						
"5-9"	(Ref)	53.3		1.00		1.00
"10-15"		46.7		0.82 (0.61,1.12)		0.83 (0.61,1.12)
Clusters' Utility						
With Electricity	(Ref)	32.2		1.00		1.00
None		67.8		1.36 (0.84,2.22)		1.36 (0.83,2.23)
Clusters' Sanitation						
Toilet	(Ref)	4.5		1.00		1.00
Pit		62.2		0.47* (0.20,1.10)		0.47* (0.20,1.12)
Open-Air/Other		33.3		0.48** (0.23,1.00)		0.48* (0.23,1.01)
Clusters' Water Supply						
Government-Piped	(Ref)	32.7		1.00		1.00
Other		19.7		0.85 (0.48,1.50)		0.82 (0.46,1.47)
Well/Pumped		47.6		1.18 (0.73,1.91)		1.16 (0.71,1.87)
		100.0				
Cluster-effect		σ_v^2 (s.e.)	0.15 (0.13)	0.05 (0.12)		
		ρ_v	0.044	0.015		
Cluster-effect (Split)						
Khartoum		σ_{v1}^2 (s.e.)			0.00 (0.0)	0.00 (0.0)
		ρ_{v1}			0.000	0.000
Eastern		σ_{v2}^2 (s.e.)			0.32 (0.43)	0.12 (0.33)
		ρ_{v2}			0.089	0.035
Central		σ_{v3}^2 (s.e.)			0.15 (0.23)	0.14 (0.23)
		ρ_{v3}			0.044	0.041
Darfur		σ_{v4}^2 (s.e.)			0.32 (0.36)	0.01 (0.24)
		ρ_{v4}			0.089	0.003
Kordofan		σ_{v5}^2 (s.e.)			0.33 (0.43)	0.23 (0.37)
		ρ_{v5}			0.091	0.065
Northern		σ_{v6}^2 (s.e.)			0.00 (0.0)	0.12 (0.59)
		ρ_{v6}			0.000	0.035

***=sig. (0.001) , **=sig. (0.05), *=sig. (0.1)

This could be in part due to the over-riding effects of other differentials in the multivariate association, or overall, the poor quality reporting of mothers age at the survey time. For Sudanese first births, the most important socio-economic differential is whether husbands' had any schooling. More precisely, the beneficial effect of the husbands' education outweighs that of mothers; first births born to mothers whose husbands' had no schooling face double the risk of death before age five compared to their counterparts. A puzzling beneficial effect is that of husbands' occupation in agriculture – unique to Sudan, there is evidence of as much as a one-third decrease in mortality risks before age five for first births to mothers whose husbands work in agriculture. This is a peculiar indication that cannot be substantiated even from life-table estimates (Chapter Four, page 135) which is perhaps raising an issue with the accuracy of reporting husband's occupational definitions. Adding-in the cluster characteristics did not increase the explanatory power of the model, but indications are towards lower risk of childhood mortality where electricity and clean water facilities are available.

One further addition to the model is a period-control which though insignificant signals slightly lower risks of death for first births cohorts born in the "10-14" years before the survey, or the late 1970s, compared to the "5-9" period before the survey, or the early to mid 1980s. Since this section includes only first births and there can only be one per household, the random effect is represent able only at the cluster level. Initially, a small cluster random effect is detected by the null model, which has a variance estimate greater than zero but remains statistically insignificant. The final model (A3) leaves an "intra-cluster" correlation coefficient of unmeasured effects of (ρ_v=.015). Using a split of the cluster-effect variance component by governates, the estimate for Khartoum reduces to zero, with Kordofan showing a slightly increased correlation coefficient (ρ_{v5}= 0.065). Yet, for all governates, there was no evidence of difference when cluster-variance components were jointly tested for equality ($\chi^2_{(6)}$=0.949 , p-value=0.9875).

In sum, estimates of the multi-level model show more than average risk for male first births in Sudan, symptomatic of underreporting of dead females first births. The typical association of young maternal age and risks of under-five mortality feature in the multi-level model, yet estimates fail to show supporting statistical significance. The strongest and most significant socio-economic influence is born by paternal schooling; over-riding the direct effects of mothers schooling, the risk of death before age five is more than doubled for Sudanese first births to illiterate fathers.

5.4.2 *Mortality of Higher-Order Births*

In modelling the mortality of higher-order births, the range of birth-specific factors extend to include the length of the preceding birth interval, the survival status of the immediately older sibling and the survival status of older siblings interacted with the birth order of the index birth. Also the model resumes the triple hierarchy where the cluster-effect operates at level 3 and the household-effect at level 2 and the birth-effect is at level 1, respectively.

In this analysis, only the results of under 5 mortality for higher-order births will be discussed shown in Tables 5.4.2A (page 179) and 5.4.2B (page 181), respectively. Table 5.4.2A, describes the final multivariate ***model A3*** with the sequential addition of birth, household and cluster characteristics, alongside ***model S3***, which has identical model specification whilst splitting the variance component at the cluster-level. Discussed later is Table 5.4.2B, which depicts the corresponding random-effect model sequence for A3 and S3, respectively.

Male births may experience poorer survival rates compared to females in the first year of life. Post-infancy, sex-difference in survival rates are expected to occur where rearing environments are favouring one sex over the other. With the extended survival time to age five as a dependent variable, Model A3, in Table 5.4.2A, estimates indicate a significant one-fifth increase in mortality risks before age five for male later births compared to their female counterparts. Rather than differential experiences in survival, the excess risk estimate is attributable largely to the under-reporting of female deaths, demonstrated by the quality assessment process (Chapter Two, Section 2.4.4, page 83).

Young and late maternal age at birth are usually associated with higher risk pregnancies, but in the case of Sudanese later births, the model-based evidence is insignificant alongside other controls in the multivariate relations. Compared to a maternal age at birth of 20-24 years, mortality risks are marginally heightened by approximately one-third, when mothers have later births aged 35 and more.

In regard to birth spacing, the odds of death before age five are 2.6 : 1 (p-value $<$ 0.001) when an index birth follows a preceding birth interval of less than 18 months compared to a longer birth interval of 24-35 months, respectively.

Table 5.4.2A Sudan Differentials of Mortality before Age 5 for Higher-Order Births *(Fixed-effects)*

Multi-level Model Correlates		N=8498 %	A3 MLOR (95% C.I.)	S3 MLOR (95% C.I.)
Sex				
Male		51.6	1.20** (1.04,1.39)	1.20** (1.03,1.39)
Female	(Ref)	48.5	1.00	1.00
Maternal age at birth				
< 18 yrs		3.6	1.36 (0.92,2.00)	1.36 (0.93,1.99)
18-19		5.9	0.85 (0.59,1.21)	0.84 (0.59,1.2)
20-24	(Ref)	25.7	1.00	1.00
25-29		27.4	1.01 (0.81,1.27)	1.02 (0.82,1.28)
30-34		21.0	1.11 (0.85,1.44)	1.11 (0.85,1.44)
35 +		16.3	1.35* (0.99,1.85)	1.35* (0.99,1.84)
Previous Birth Interval				
< 18 month		26.1	2.60*** (2.15,3.14)	2.60*** (2.16,3.14)
18-23 month		18.5	1.20 (0.95,1.50)	1.20 (0.96,1.51)
24-35 month	(Ref)	32.2	1.00	1.00
36+ month		23.2	0.67*** (0.52,0.86)	0.67*** (0.53,0.86)
Previous Child Survived to Birth of Index Child				
Yes (Ref)		90.0	1.00	1.00
No		10.0	1.11 (0.90,1.37)	1.13 (0.92,1.40)
Birth Order X Previous Deaths				
B2-3 X 0 death	(Ref)	33.1	1.00	1.00
B4-6 X 0 death		25.9	0.92 (0.73,1.16)	0.92 (0.73,1.15)
B7+ X 0 death		9.7	0.87 (0.61,1.24)	0.86 (0.61,1.22)
B2-3 X 1 death		2.5	1.75** (1.13,2.70)	1.77*** (1.15,2.72)
B4-6 X 1 death		9.8	1.23 (0.93,1.62)	1.24 (0.94,1.63)
B7+ X 1 death		7.1	1.08 (0.75,1.54)	1.08 (0.76,1.54)
B4-6 X 2+ deaths		3.4	0.90 (0.60,1.36)	0.91 (0.60,1.37)
B7+ X 2+ deaths		8.6	0.96 (0.68,1.35)	0.96 (0.69,1.34)
Area of Residence				
Urban	(Ref)	33.4	1.00	1.00
Rural		66.6	0.86 (0.67,1.10)	0.85 (0.67,1.07)
Mother attended School				
No		70.4	1.49*** (1.17,1.90)	1.51*** (1.19,1.92)
Yes	(Ref)	29.6	1.00	1.00
Husband attended School				
No		42.6	1.43*** (1.16,1.77)	1.41*** (1.14,1.74)
Yes	(Ref)	57.4	1.00	1.00
Husband in Agriculture				
No	(Ref)	40.4	1.00	1.00
Yes		59.6	1.01 (0.82,1.23)	1.01 (0.83,1.23)
Years before the Survey				
"5-9"	(Ref)	55.2	1.00	1.00
"10-15"		44.8	0.98 (0.84,1.15)	0.98 (0.84,1.14)
Clusters' Utility				
Electricity	(Ref)	30.1	1.00	1.00
None		69.9	0.91 (0.68,1.23)	0.95 (0.71,1.26)
Clusters' Sanitation				
Toilet	(Ref)	4.7	1.00	1.00
Pit/ Laterine		63.2	1.74* (0.93,3.27)	1.82* (0.97,3.42)
Open-Air/Other		32.1	1.71* (0.97,3.03)	1.84** (1.03,3.28)
Clusters' Water Supply				
Government-Piped	(Ref)	31.7	1.00	1.00
Other		49.7	1.55** (1.09,2.20)	1.29 (0.92,1.82)
Well/Pumped		18.6	1.19 (0.89,1.60)	1.12 (0.84,1.49)
		100.0		

***=sig. (0.001) , **=sig. (0.05), *=sig. (0.1)

On the beneficial side, longer birth intervals of more than 36 months would reduce the risk of death before age five for the index later births substantially by a significant one-third.

The previous familial mortality measures, represented by the two variables – the survival status of the previous child and the birth order group interacting with older sibling deaths, show surprisingly weaker influences than anticipated. One in ten later births were born after the death of the immediately preceding birth. In the final multi-level model (model A3), the effect of the survival status of the immediately previous child on survival chances to age five, shows no evidence of the customary excess risk associated with it. Significant excess risk estimates occur only for second or third birth orders with a dead firstborn sibling; those constitute about 5 per cent of later births. On average, the increased risks are 75 per cent higher compared to their counterparts with a surviving firstborn sibling. Fundamentally, controlling for the survival status of the immediately preceding birth and the length of the preceding birth interval has almost eliminated the correlation of the index birth to older siblings' survival status.

Next to consider are the socio-economic correlates of survival to age five. Unlike the situation with first births, where the effect of husbands lack of schooling over-rides any advantages of mothers schooling, lack of paternal schooling bears almost equal shares of extra risk of death before age five for later births. Births to mothers with no schooling suffer close to half as more extra risk of death before age five compared to those born to mothers with some schooling. Similarly, births to mothers whose husbands had no schooling show 43 per cent extra risk of death before age five compared to those born to mothers whose husbands had any schooling.

The clusters contextual characteristics show later births residence in clusters lacking piped or pumped water supplies with 55 per cent extra risk of death before to age five compared to their counterparts – in splitting the variance component by region (model S3), this difference deems to insignificance and loses magnitude. Compared to clusters with "Toilet" sanitation, residence of higher order births in clusters relaying on "Pit" or "Open air" sanitation is associated with at least a two-third increase in risks of under-5 mortality, but the association is marginally significant.

The random-effects presented at the continued part as Table 5.4.2B; the null model initially picks-up formidable and significant cluster and household random effects ("intra-cluster" correlation, ρ_v= 0.042, "intra-household" correlation ρ_u= 0.306).

Table 5.4.2B Sudan Differentials of Mortality before Age 5 for Higher-Order Births ***(Fixed-effects)***

Random-effects	N=8498	A0 (Null)	A3	S0 (Null)	S3
Cluster-effect	σ_v^2 (s.e.)	0.20*** (0.07)	0.10** (0.05)		
	ρ_v	0.042	0.024		
Household-effect	σ_u^2 (s.e.)	1.25*** (0.15)	0.81*** (0.12)		
	ρ_u	0.306	0.217		
Cluster-effect (Split)					
Khartoum	σ_{v1}^2 (s.e.)			0.04 (0.12)	0.00 (0.0)
Eastern	σ_{v2}^2 (s.e.)			0.38 (0.24)	0.26 (0.18)
Central	σ_{v3}^2 (s.e.)			0.06 (0.09)	0.02 (0.07)
Darfur	σ_{v4}^2 (s.e.)			0.45** (0.20)	0.22* (0.13)
Kordofan	σ_{v5}^2 (s.e.)			0.00 (0.0)	0.00 (0.0)
Northern	σ_{v6}^2 (s.e.)			0.70 (0.52)	0.70 (0.49)
Household-effect	σ_u^2 (s.e.)			1.20*** (0.14)	0.76*** (0.11)
Khartoum	ρ_{v1}			0.009	0.000
Household	ρ_u			0.274	0.188
Eastern	ρ_{v2}			0.078	0.060
Household	ρ_u			0.324	0.237
Central	ρ_{v3}			0.013	0.005
Household	ρ_u			0.277	0.192
Darfur	ρ_{v4}			0.091	0.052
Household	ρ_u			0.334	0.229
Kordofan	ρ_{v5}			0.000	0.000
Household	ρ_u			0.267	0.188
Northern	ρ_{v6}			0.135	0.147
Household	ρ_u			0.366	0.307

***=sig. (0.001) , **=sig. (0.05), *=sig. (0.1)

With the progression to the final multivariate model (A3), both measures are reduced to ρ_v = 0.024 and ρ_u = 0.217, respectively, with both *parent* variance-components remaining significant. The bio-demographic variables (sex, maternal age at birth and the length of the preceding birth intervals) and the familial measures of child losses roughly contribute to equal shares of that drop in value.

When the variance-split is deployed, as shown by Table 5.4.2B Khartoum and Kordofan variance-components at the cluster-level reduce to zero, but since the household-effect remains substantial, the "intra-household" correlation holds at ρ_u= 0.188 ; a situation similarly found in the Central governate (ρ_u= 0.192). For the Northern, Eastern and Darfur governates the cluster-effects are sizeable yet insignificant leaving substantial "intra-household" correlation ρ_u= of 0.307, 0.237

and 0.229, respectively. Jointly tested, estimates of the governates cluster variance components were close to zero ($\chi^2_{(6)}$=7.108 , p-value=0.311).

Since a considerable "intra-household" correlation will indicate household-family environments are more heterogeneous than expected if clustering was ignored, it follows that a child's survival chance are affected by intrinsic household-specific risk factors in these settings. The contextual variables employed add little to explain random effects.

In sum, for *all* births, a clear sex differential in mortality was estimated to the disadvantage of male births; partly explained by under-reporting of female deaths, especially when they are firstborns. Lack of maternal and paternal education bears a considerable risk to all births. For first births the cluster random-effects are not apparent and hence that alleviates the need for a multi-level model. But in the case of higher-ordered birth there is a considerable element of unmeasured heterogeneity between households, but scarcely between clusters. After the first year of life, children's survival chances are more affected by their socio-economic and environment surroundings. Yet one immediate measure of the survival conditions in these surroundings in the survival status of previous births within the same unit. This proxy measure of the effect of "unmeasured" factors at the household level, yet a considerable correlation in survival chances remains unexplained. A number of manifestations unmeasurable by a sample-survey can be behind such a correlation; these could include malaria manifestation, malnutrition, accessibility of health care services, perhaps operating at higher levels of the hierarchy (that is the community, village or cluster) and are deposited at the household level.

5.5 Yemen

Finally the live-births history for Yemen is considered, which consists of 257 residential clusters providing 29,803 children. The analysis of under-5 mortality entails more censoring of recent births and hence the sub-sample provides 257 clusters with a total of 4,834 households and 15,094 births born in the period 5-15 years before the survey. It is also worth noting that the sample for Yemen was not a self-weighted sample to guarantee appropriate representation of urban and rural areas. Goldstein (1995: p.5) advises although the direct modelling of clustered data is statistically efficient, it will generally be important to incorporate weights in the analysis that will reflect the sample design to obtain robust population estimates and so that there will be some protection against model misspecification. Thus, all the analysis shown below include an adjustment with sampling weights applied at the household level.

Fig. 5.5: Distribution of the Multi-level Design for the Sample of Births, **YDMCHS (1991/92).**

Regions	No. of Clusters	No. of Household	No. of Births	Mean no. of Births per Household (S.D)	Median no. of Births per Household (IQR)
North and West	177	2,988	11,650	3.90 (2.04)	4 (2,5)
South and East	80	1,057	3,444	3.26 (1.81)	3 (2,4)
Total	257	4,045	15,094	3.73 (2.00)	4 (2,5)

In Figure 5.5 above, the regional distribution shows the "North & West" with the greater share of the sample size and average a higher number of births contributed per unit of level 2 or per household. Also the clusters distribution further identifies the "North & West" region with more than double the contribution of residential clusters compared to the "South & East" region. The "North & West" region is spatially wider and population-wise denser of the two regions. Because of higher fertility levels, the average number of children contributed by each household is higher for Yemen. The interpretation to follow is of the final multivariate model obtained, indexed as Model A3 (and S3).

5.5.1 Mortality of First Births

For the analysis of first births, two tables were produced. Table 5.5.1 illustrates in the next page, the analysis of first birth mortality before age five with two multilevel models, A3 and S3, respectively. Starting with the gender differential, model A3 estimates that male first births carry about 30 per cent excess risk of mortality before age five compared to their female counterparts – yet this substantial and significant magnitude of increased risk could be a result of the under-reporting of mortality events of female first births. When mothers age at first birth is younger than 18 years, the most prevalent group characterising one-third of Yemeni first births, a one-third rise in mortality risk before age five is estimated compared to the risks of first births born to mothers aged 20-24. Estimates of differential lower risks at higher maternal age groups are weak, but this in part is due to small numbers. More than four-fifths of first births are to mothers with no schooling – hence, it comes as no surprise to observe weak associations of maternal schooling and child survival. There is no evidence to suggest beneficial effects of husbands' schooling in this instance.

Table 5.5.1 Yemen Differentials of Mortality before Age 5 for First Births

Multi-level Model Correlates	N=2391 (%)	A0 (Null)	A3 MLOR (95% C.I.)	S0 (Null)	S3 MLOR (95% C.I.)
Sex					
Male	51.0		1.30** (1.03,1.63)		1.29** (1.03,1.63)
Female (Ref)	49.0		1.00		
Maternal age at birth					
< 18 years	33.3		1.33** (1.00,1.76)		1.33** (1.00,1.76)
18-19	19.5		0.96 (0.68,1.35)		0.96 (0.68,1.35)
20-24 (Ref)	31.6		1.00		1.00
25-29	9.7		0.73 (0.46,1.16)		0.73 (0.46,1.16)
30-34	4.2		1.38 (0.80,2.38)		1.38 (0.80,2.39)
35 +	1.7		0.71 (0.20,2.54)		0.70 (0.20,2.5)
Area of Residence					
Urban (Ref)	22.7		1.00		1.00
Rural	77.3		0.67 (0.41,1.09)		0.67* (0.41,1.08)
Mother attended School					
No	85.5		1.33 (0.84,2.10)		1.33 (0.85,2.09)
Yes (Ref)	14.5		1.00		1.00
Husband attended School					
No	60.9		1.05 (0.79,1.41)		1.05 (0.79,1.40)
Yes (Ref)	39.1		1.00		1.00
Husband in Agriculture					
No (Ref)	74.3		1.00		1.00
Yes	25.7		1.45*** (1.10,1.90)		1.45***(1.11,1.90)
Years before the Survey					
"5-9"	48.7		1.00		1.00
"10-15"	51.3		1.09 (0.86,1.37)		1.08 (0.86,1.37)
Clusters' Utility					
Electricity (Ref)	50.3		1.00		1.00
Kerosene	49.7		1.11 (0.80,1.54)		1.12 (0.81,1.54)
Clusters' Sanitation					
Toilet (Ref)	16.2		1.00		1.00
Pit/Latrine	42.0		2.05** (1.18,3.54)		2.02** (1.17,3.46)
Open-Air/Other	41.8		2.10** (1.14,3.85)		2.05** (1.13,3.75)
Clusters' Water Supply					
Govern-Piped (Ref)	38.6		1.00		1.00
Well/Pumped	43.3		0.99 (0.68,1.44)		0.99 (0.69,1.44)
Other	18.1		1.03 (0.66,1.59)		1.03 (0.67,1.60)
	100.0				
Cluster-effect	σ_v^2 (s.e.)	0.23** (0.09)	0.16* (0.09)		
	ρ_v	0.065	0.046		
Cluster-effect (Split)					
North and West	σ_v^2 (s.e.)			0.26** (0.11)	0.18* (0.09)
	ρ_v			0.073	0.052
South and East	σ_v^2 (s.e.)			0.07 (0.18)	0.05 (0.21)
	ρ_v			0.021	0.015

***=sig. (0.001) , **=sig. (0.05), *=sig. (0.1)

Conversely, a marked socio-economic disadvantage is associated with births to mothers whose husbands' occupation are in agriculture, For those, the odds of death before age five rise by 45 per cent compared to their counterparts. The cluster-contextual factor describing cluster sanitation identifies doubling risks of mortality before age five for first births belonging to clusters where sanitation is "Pit/ Latrine" or "Open Air", compared to those belonging to clusters with "Toilet" sanitation.

The bottom entries of Table 5.5.1 (previous page) illustrate estimates of the variance components of unmeasured cluster-effect. The random-effect shows a significant and sizeable variance-component at first in the null model with an estimated "intra-cluster" equalling $\rho_v = 0.065$. The component lessens gradually in size and significance with the addition of more variables to the model and maintains marginal significance in the final multivariate model with a reduced "intra-cluster" correlation equalling $\rho_v = 0.046$. When the cluster variance-component was split by region ("North & West" and "South & East"), shown by model S3, the random cluster effect appears to be solely generated by the "North & West" region. For this region heterogeneity suggests certain clusters may marginally bear more than average risk effects on the survival chances of these first births. However, a joint test of equality shows that the two estimates of the clusters variance-components are not different from zero ($\chi^2_{(2)}=3.667$, p-value=0.1599).

Overall, first births in Yemen suffer the adverse effect of young mothers' age at birth, with evidence of slightly higher risks for male births and where births are to fathers working in agriculture or belong to residential clusters with no "Toilet" sanitation. Also, higher risks due to an unmeasured cluster-effect are a product of some heterogeneity in mortality risks, prevalent in the "North & West" region rather than the whole country.

5.5.2 *Mortality of Higher-Ordered Births*

The focus of this section is the interpretation of the multilevel modelling of under-5 mortality, shown in Tables 5.5.2.A (page 186) and 5.5.2.B (page 189), respectively. More moderately than what was observed with first births, male later births show slightly higher and significant risks of death before age five compared to their counterparts.

With maternal age at birth, model A3 shows a protective effect of 14 per cent lower mortality risks on average when mothers are aged 25-29 years at the time of a later birth compared to age 20-24 years. The protective effects of central maternal ages further extend to the maternal age 30-34, but estimates only show marginal significance.

Table 5.5.2A Yemen Differentials of Mortality before Age 5 for Higher-Order Births ***(Fixed-effects)*** **Multi-level Model**

Correlates		N=12703	A3 MLOR (95% C.I.)	S3 MLOR (95% C.I.)
Sex		**(%)**		
Male		52.0	1.13** (1.01,1.26)	1.13** (1.01,1.26)
Female	(Ref)	48.0	1.00	1.00
Maternal age at birth				
< 18 yrs		4.3	1.08 (0.84,1.40)	1.08 (0.84,1.40)
18-19		6.9	0.92 (0.74,1.15)	0.92 (0.74,1.15)
20-24	(Ref)	26.4	1.00	1.00
25-29		26.5	0.86** (0.74,1.00)	0.86** (0.74,1.00)
30-34		18.7	0.84* (0.70,1.00)	0.83** (0.70,1.00)
35 +		17.3	0.94 (0.75,1.18)	0.94 (0.75,1.18)
Previous Birth Interval				
< 18 month		44.8	2.87*** (2.43,3.39)	2.87*** (2.44,3.39)
18-23 month		17.5	1.62*** (1.33,1.99)	1.63*** (1.33,1.99)
24-35 month	(Ref)	20.8	1.00	1.00
36+ month		16.9	0.63*** (0.49,0.81)	0.62*** (0.48,0.80)
Previous Child Survived to Birth of Index Child				
Yes (Ref)		85.4	1.00	1.00
No		14.6	1.64*** (1.43,1.88)	1.65*** (1.44,1.89)
Birth Order X Previous Deaths				
B2-3 X 0 death	(Ref)	32.3	1.00	1.00
B4-6 X 0 death		22.8	0.79*** (0.67,0.94)	0.79*** (0.67,0.94)
B7+ X 0 death		5.7	0.75* (0.55,1.04)	0.75* (0.55,1.04)
B2-3 X 1 death		3.1	1.45*** (1.10,1.92)	1.45*** (1.10,1.91)
B4-6 X 1 death		11.5	1.30*** (1.08,1.56)	1.29*** (1.08,1.55)
B7+ X 1 death		6.3	1.23 (0.94,1.61)	1.24 (0.95,1.62)
B4-6 X 2+ deaths		5.7	1.02 (0.80,1.30)	1.03 (0.81,1.31)
B7+ X 2+ deaths		12.5	1.28** (1.04,1.58)	1.29** (1.04,1.59)
Area of Residence				
Urban	(Ref)	23.4	1.00	1.00
Rural		76.6	1.27* (0.97,1.66)	1.26* (0.96,1.65)
Mother attended School				
No		94.1	1.23 (0.91,1.65)	1.24 (0.92,1.67)
Yes	(Ref)	5.9	1.00	1.00
Husband attended School				
No		75.7	1.23** (1.04,1.45)	1.24*** (1.05,1.47)
Yes	(Ref)	24.3	1.00	1.00
Husband in Agriculture				
No		68.0	1.00	1.00
Yes	(Ref)	32.0	1.09 (0.95,1.24)	1.10 (0.96,1.25)
Years before the Survey				
"5-9"	(Ref)	57.8	1.00	1.00
"10-15"		42.2	1.33*** (1.19,1.49)	1.33*** (1.19,1.49)
Clusters' Utility				
With Electricity	(Ref)	52.4	1.00	1.00
Kerosene		47.6	1.33*** (1.11,1.58)	1.28*** (1.08,1.52)
Cluster Sanitation				
Toilet	(Ref)	16.9	1.00	1.00
Pit/Latrine		41.6	1.21 (0.91,1.60)	1.24 (0.94,1.64)
Open-Air/Other		41.5	1.30 (0.95,1.78)	1.38** (1.01,1.89)
Cluster Water Supply				
Government-Piped	(Ref)	40.4	1.00	1.00
Well/Pumped		40.9	0.99 (0.81,1.21)	0.99 (0.82,1.21)
Other		18.7	0.97 (0.77,1.23)	0.97 (0.77,1.22)
		100.0	***=sig. (0.001) , **=sig. (0.05), *=sig. (0.1)	

Children born shortly after a previous birth experience considerable excess mortality risks. Short preceding birth intervals of less than 18 months characterise 45 per cent of later births, which exerts close to a three-fold increase in their odds of death before age five compared to those following an interval of 24-35 months. Even when preceding birth intervals are 18-23 months, the magnitude of increased risk (about two-third increase) is substantial and strongly significant. Only one in six later births follow prolonged birth intervals of three years or more, which on average reduces their mortality risk by at least one-third compared to the baseline group.

Net of the effects of birth spacing, the death of the immediately preceding child prior to the birth of the index later birth, exerts close to a two-third increase in the odds of the latter's death before age five. On their own right, counts of older siblings' deaths show considerable excess risk for later births. First to note is that higher parity groups, in a setting of all older siblings still alive, would have considerably lower risks of death which is perhaps contrary to what is expected under an assumption of siblings' competition. For seventh and higher order births the survival advantage associated with surviving older siblings show a marginally significant one-quarter drop in mortality risk before age five.

Put together, fourth and higher-order birth with surviving older siblings are substantial (28.5 per cent of later births) and hence estimates are suggesting reduced mortality risks in household settings of better surviving rates. Despite their small percentage, the odds of death are 45 per cent higher for second or third births with one older sibling death. The percentage of fourth to sixth order births is more considerable and on average, their odds of death are 30 per cent higher if there was one older sibling death to the same mother.

The incidence of two or more deaths of older sibling leaves the parity group 7+ with the magnitude of 28 per cent excess risk of death before age five. Interesting to note is that the estimate of excess risks attenuates consistently as births and deaths are farther apart with regard to birth order.

Turning the focus to socio-economic correlates, the multivariate model A3 suggests later births in rural residence to be associated with a marginally significant 27 per cent excess risk of mortality before age five compared to urban residence. Similar to the evidence encountered with first births, mothers' schooling seems to have little effect in bettering chances of survival for their children, which seems quite plausible given that less than one in ten mothers is educated. Yet, the negative effects associated with the lack of paternal schooling maintain significance and indicate a moderate rise of 23 per cent in the odds of death before age for later births.

Commonly clusters with piped water supply, toilet sanitation and links to electricity supply are expected to yield better survival environments for children. For Yemeni later births, the cluster-contextual factors show significantly a one-third increase in mortality risks when their clusters of residence lack electricity-supply. An interesting result accompanies the estimates associated with clusters sanitation and splitting the variance component by region. Here, residence in clusters with "Open-air" sanitation, characterising two-fifth of later births, could pose close to a two-fifths increase in the risk of death before age five for later births, in comparison to their counterparts belonging to clusters with "Toilet" sanitation.

The remaining fixed-effect to consider is that capturing period changes in mortality levels, which shows the earlier period "10-14" years before the survey with a one-third increased estimate of risk compared to the more recent period, "5-9" years before the survey. This is clear and significant evidence of the pace of the mortality transition that took place between the late 1970s and the mid 1980s in Yemen.

Turning to random-effects, the model estimates from models A3 and S3 are shown by Table 5.5.2B (in the next page). Initially the null model detects significant and sizeable variance-components for both the cluster and household effects resulting in an estimated "intra-cluster" correlation of ρ_v= 0.045 and an "intra-household" of ρ_u= 0.175, respectively. Not shown by Table 5.5.2B, the model with all birth-specific factors, including previous mortality indicators the household-effect variance component estimate reduces to a minimal value of σ^2_u= 0.06 (with an "intra-household" correlation coefficient of size ρ_u= 0.046) and loses significance. But, with the addition of the remaining socio-economic and cluster-contextual variables, the variance-component recovers, albeit at a slower rate, and regains magnitude and significance. As can be seen from Table 5.5.2B, the two variance components of the random effects at the cluster and household levels, respectively, though smaller in magnitude, remain highly significant in the final models, whether ***A3*** or ***S3*** is considered. What would the implications be? Model ***A3*** significantly indicates an intra-cluster correlation coefficient of size ρ_v= 0.023 with an intra-household correlation coefficient of size ρ_u= 0.065 respectively. This means that survival chances are expected to be more heterogeneous between clusters, and further still between households belonging to the same cluster.

Table 5.5.2B Yemen Differentials of Mortality before Age 5 for Higher-Order Births

Random-Effects	N=12703	A0 (Null)	A3	S0 (Null)	S3
Cluster-effect	$\sigma_v{}^2$ (s.e.)	0.18*** (0.04)	0.08***(0.03)		
	ρ_v	0.045	0.023		
Household-effect	$\sigma_u{}^2$ (s.e.)	0.52*** (0.07)	0.15***(0.05)		
	ρ_u	0.175	0.065		
Cluster-effect (Split)					
	$\sigma_{v1}{}^2$ (s.e.)			0.13*** (0.04)	0.05* (0.02)
	$\sigma_{v2}{}^2$ (s.e.)			0.52*** (0.15)	0.28** (0.11)
Household-effect (Split)					
North and West	$\sigma_{u1}{}^2$ (s.e.)			0.70*** (0.09)	0.17** (0.07)
South and East	$\sigma_{u2}{}^2$ (s.e.)			0.60** (0.24)	0.11 (0.08)
North and West	ρ_{v1}			0.032	0.014
Household	ρ_{u1}			0.201	0.063
South and East	ρ_{v2}			0.118	0.076
Household	ρ_{u2}			0.254	0.106

***=sig. (0.001) , **=sig. (0.05), *=sig. (0.1)

One striking finding is that when the variance-component is split at the cluster level by the country's two regions, the larger of the two is the one belonging to the "South & East" region (contrary to the equivalent finding with the analysis of first births). More impressively, and unique to Yemen, when the attempt was made to split the household-effect by region, as with the over-arching cluster-effect, the multi-level model with capable of producing convergent 2nd order PQL estimates of the variances components. With the estimation of model S3, results are even more revealing than expected: firstly, for later births belonging to the "South & East", more crucial is that sustained heterogeneity estimated by the cluster-effect significant variance component (with an "intra-cluster" correlation ρ_{v2}= 0.076). Secondly, the multivariate relations in model S3 considerably reduces the sizes and significance of the two the variance components at the cluster and household levels, respectively. Yet the household-effect variance component persists in significance (with an "intra-household" correlation ρ_{u1}= 0.055), whilst that of the cluster-effects weakens. At a glance households in the "South & East" appear to have twice the size of the "intra household" correlation as that estimated for the "North & West" region, all being equal. Yet, the estimate of the correlation in the "South & East" is largely attributable to the overbearing cluster rather than household effects.

For the random coefficients of model *S3*, the regional cluster variance-components, tested jointly, are significantly different from zero ($\chi^2_{(2)}$=10.07, p-value=0.0065) and similarly, a joint test of the regional household variance-components demonstrates significant inequality to zero ($\chi^2_{(2)}$=8.41, p-value=0.015).

To summarise findings for Yemen, there is evidence of moderate gains in child survival with more central maternal ages at birth. There is a sex differential in mortality, perhaps more severe in the case of first births compared to later births, due in part to the under-reporting of female deaths. The detrimental effects of short preceding birth intervals is unequivocal – convincingly, the protective effects are evident once birth intervals are prolonged to two years or more. Older siblings mortality indicates trailing correlations in survival, and rather, that the survival status of the immediately previous child is a better proxy for the immediate "familial mortality" risks to the index births.

The lack of explanatory power of the socio-economic differentials is perhaps indicative of a low ceiling of the economic advantages commonly associated with factors such as better education and urban residence. Also early childhood mortality implies that children live too-short a time to benefit from slim socio-economically advantaged settings. With regard to cluster characteristics, only in Yemen did the lack of opportunities associated with access to utilities show significant effects on child survival, in the presence of dominant multivariate relations. Unmeasured effects operating at the cluster and household levels were clearly detected by the multilevel logistic model. Surprisingly, the splitting of the variance components was successful both at the cluster and household levels. The "South & East" region emerges with evidence of more heterogeneity in children's survival chances attributable more to perhaps to exogenous cluster-level factors, such as services availability and accessibility. Whilst, the stronger heterogeneity exists for the "North & West" region at the household level, perhaps pointing more in the direction of parental practices and household living and economic conditions.

5.6 Summary and Discussion

When a sample survey is carried out the sample design typically mirrors the hierarchical population structure, in terms of geography and household membership. The data units used in this analysis are entries of maternity histories, which reflect more than one level of structural clustering. Two distinguishable levels are the schematic sampling-design clustering of households or women within geographical clusters and the more obvious of children belonging to the same mother.

It was customary for demographic research work using maternity history data to ignore such structural correlations. Yet a number of studies carried-out in the last decade recognised and emphasised the importance and relevance of that natural structure. The prime aim was to capture key effects but with correct standard errors, confidence intervals and significance tests, generally more "conservative" than the traditional ones obtained by ignoring the presence of clustering. Hence, a hierarchical logistic model was deployed to model child mortality, to observe changes to fixed-effects, and to further recognise random-effects where applicable.

Three sets of factors were hypothesised to be affecting child mortality;

1. Those particular to the index birth in question: sex, maternal age at the birth of the index child, the preceding birth interval and measures of the survival status of older siblings. There was a marked sex differential in mortality before age five in the cases of Sudan and Yemen, disadvantageous to male births, largely attributable to under-reporting of female deaths, but not in Egypt. The typical U-shaped association of child mortality with maternal age at birth, generally, held significance only for Egypt, but was weaker in the cases of Sudan and Yemen; perhaps questioning the accuracy of mothers age reporting at the time of the survey. Shorter birth intervals, more commonly occurring in Sudan and Yemen, are sure to at least double the risk of death before age five in the three settings. It was imperative to control for the survival status of the preceding birth in the three sub-samples. Indicators of familial-history of older siblings deaths "screen" risks in survival for later births, more prominently in the case of Egypt and more moderately in the cases of Sudan and Yemen.

2. Those particular to the woman or household: the occupation and educational attainment of the respondent's husband, the educational attainment of the respondent herself and the type of residential area. The role of maternal schooling in reducing child mortality is well-identified, but the overall advantage varies across countries. For Egypt and Sudan the percentage of births born to mothers with no schooling is quite comparable yet the extent of the extra risk associated with the lack of mothers' schooling is higher in

Sudan than Egypt. For Yemen, the realisation of the advantages of maternal schooling are moderate given that less than one in ten mothers is literate. A similar scenario as that noted with maternal schooling is observed with the beneficial effects of paternal education. When fathers' occupation is agricultural, the associated familial economic disadvantage to child survival are more implied in the case of Yemen than in Egypt and Sudan. With the exception of Egypt, survival disadvantage associated with rural residence were reduced to non-significance when other socio-economic characteristics were adjusted for.

3. Those particular to the cluster in which the woman and child dwells: the essence of using clusters contextual characteristics is to identify advantaged settings which yield better survival opportunities, and to observe whether they play a role in capturing unmeasured effects at the cluster-level. The clusters' sanitation provision had marked significance in Egypt where "Toilet" sanitation was absent, which applies to a quarter of clusters, and thus the higher estimates of risk. Further, Yemen shows beneficial effects to children's survival chances in clusters with the development opportunities associated with electricity supply. Although estimates in general showed little significance, the indications are towards lower risks of death for clusters with piped rather than pumped water supplies.

With the random effects, the results add a further contrast. The sizeable random effect appears at the household-level more than at the cluster level. In the case of Sudan that effect is partially explained by all three types of fixed-factors mentioned above but still, considerable correlation remains within households – this translates into characterising certain households with more than average (or less than average) risks of child losses. The unmeasured random-effect at the household-level was completely explained, in the case of Egypt, specifically with the addition of measures of *its* previous child mortality. Yemen is halfway between the two previous cases with regard to the residual "intra-household" correlation; a reduction primarily brought about by controlling for birth-specific factors.

The splitting of the random-effect at the cluster level into respective regions or governates components proved to be insightful. It can further be asserted that splitting the variance component did not perturb any of the estimates of the fixed-effect. Also, it has revealed certain regions with close to zero random-effects and others with higher estimates than those suggested by a single variance-component estimate. The cluster random effect could hence be defused by the observed correlates of the resulting multivariate models for some regions, but not others. In the case of Egypt, the Urban Governates (Cairo, and Alexandria) and Upper Rural Egypt, showed considerable estimates of unmeasured heterogeneity at the cluster level. Yet the nature of heterogeneity is too dissimilar. One example, is in how health facilities and staff tend to be unevenly distributed nationally, clustering in urban areas, especially in Cairo and Alexandria (WHO/EMRO, 1996). In the case of Sudan, some marginally significant heterogeneity holds in Darfur at the cluster-level. Yet, overwhelmingly and across Northern Sudan, considerable heterogeneity in mortality risks operate at the household level. In the case of Yemen, and based on the literature evidence, the "South & East" region had a head-start in the implementation of PHC policies and its derivatives. On splitting the variances of unmeasured effects by region, results could explain the previous notion. The unmeasurable factors manifests more at the cluster rather than the household level in "South & East" Yemen. Here, heterogeneity could question, as in the case of the Urban Governates of Egypt, the availability and access to health-related resources at the cluster level. Conversely, the "North & West" region of Yemen, shows perhaps more homogeneity at the cluster level, yet more heterogeneity at the household level – here the interpretation could borrow from the findings of Myntti (1993) who observed that what distinguished women with healthy and unhealthy children was the level of resources under their control and the way they managed them; their social support or lack of it; and their passive or active attitudes toward life.

It is also worth noting that fitting complex variation at level 2 (between households or mothers) and level 3 (between clusters) did not yield statistically significant effects.

The Implications of Unmeasured / Unmeasurable effects:

Following the approach used by earlier studies (Curtis, Diamond, and McDonald, 1993; Pebley, Goldman, and Rodriguez, 1996; and, Curtis and Steele, 1996) the extent of variation in under five mortality risks can be examined by estimating probabilities of under five mortality for selected characteristics for different values of the standardised random effects at the cluster and household levels. Table 5.6 (page 195-196) shows selective predicted probabilities of death before age five for the Sudan, Egypt and Yemen respectively, using ***model A3*** that adjusts for birth, household and cluster-specific factors. For the fixed part of ***model A3***, probabilities are calculated for each variable whilst controlling for other variables in the model and holding those at their baseline (reference) level. The parameter estimates of ***model A3***, predictions are made for three states, when the cluster random-effect is below average (-2 S.D. or –2 times the square root of the variance-component), average (zero) or above average (+2 S.D. or +2 times the square root of the cluster variance-component), respectively. Since the household-effect is adjoined to the cluster-effect, three household-effect states (similar to the previously described ones) will be probable within each cluster-effect state. Favourable unmeasured effects place households and clusters below (-ve) average and unfavourable unmeasured effects place households and cluster above average (+ve). Also, Table 5.6 illustrates different scenarios of combinations of characteristics. The variation in the probability of death across families will be less for children whose characteristics place them at lower overall risk of death before age five, but greater for children with higher overall risks of death. On the whole, the real implications of predictions of probabilities of death exist when there are substantial unmeasured household-effects. In the case of Sudan, a household with a negative average effect, at an average cluster-effect (i.e. cluster effect=0), the "actual" estimated probability of death, in one-sixth that of an *average* household, while a household with a positive average effect will have an estimated probability close to five times that of an *average* household.

In the case of Egypt, the same contrast is that a negative average household has about 20 per cent less than the estimated probability of death of an average household, and a positive average household will have 20 per cent more on that of the average household, respectively. Thus, the estimated probabilities are not all that different, since the correlates of model A3 "explained" unmeasured effects at the household level in the case of Egypt. Similarly, for Yemen, a negative average household has half the estimated probability of death of an average household, but a positive average household could have two times the estimated probability of death of the average household, respectively.

Table 5.6. Higher-order Births - Predicted Probability of death before Age 5 Years (deaths / 1000 livebirths)

		Model A3	Cluster-Effect								
Egypt	N=13263		- average			average			+ average		
	%	Household-effect	-ve	av	+ve	-ve	av	+ve	-ve	av	+ve
Maternal age at birth											
< 18 yrs	2.7	1.43** (1.08,1.89)	33	41	52	63	*79*	97	118	145	176
18-19	5.1	1.04 (0.83,1.32)	24	31	38	47	*59*	73	89	110	135
20-24 (Ref)	27.0	1.00	23	29	37	45	*56*	70	86	106	130
25-29	29.7	0.89 (0.77,1.03)	21	26	33	40	*51*	63	77	95	118
30-34	21.4	0.80** (0.67,0.96)	19	24	30	36	*46*	57	70	86	107
35 +	14.0	0.90 (0.72,1.12)	21	26	33	41	*51*	63	77	96	118
Previous Birth Interval											
< 18 month	24.0	2.81*** (2.45,3.22)	63	78	97	117	*144*	175	208	249	295
18-23 month	17.4	1.49*** (1.27,1.74)	34	43	54	66	*82*	101	122	150	182
24-35 month (Ref)	28.7	1.00	23	29	37	45	*56*	70	86	106	130
36+ month	29.8	0.56*** (0.47,0.67)	13	17	21	26	*32*	41	50	62	77
Previous Child Survived to Birth of Index Child											
Yes (Ref)	85.9	1.00	23	29	37	45	*56*	70	86	106	130
No	14.1	1.39*** (1.21,1.58)	32	40	50	62	*76*	95	115	141	172
Birth Order X Previous Deaths											
B2-3 X 0 deaths (Ref)	39.8	1.00	23	29	37	45	*56*	70	86	106	130
B4-6 X 0 deaths	20.9	1.07 (0.9,1.27)	25	31	39	48	*60*	75	91	113	138
B7+ X 0 deaths	3.3	1.57*** (1.13,2.17)	36	45	56	69	*86*	106	128	156	190
B2-3 X 1 deaths	3.4	1.82*** (1.41,2.36)	42	52	65	79	*98*	121	146	177	214
B4-6 X 1 death	12.0	1.76*** (1.48,2.10)	40	50	63	77	*95*	117	142	173	208
B7+ X 1 death	4.6	1.56*** (1.17,2.06)	36	45	56	69	*85*	105	127	155	189
B4-6 X 2+ deaths	5.4	1.96*** (1.56,2.46)	45	56	69	85	*105*	129	155	188	226
B7+ X 2+ deaths	10.6	1.87*** (1.51,2.32)	43	53	66	81	*100*	123	149	181	218
Area											
Urban (Ref)	34.1	1.00	23	29	37	45	*56*	70	86	106	130
Rural	65.9	1.22** (1.03,1.43)	28	35	44	54	*68*	84	102	126	154
Mother attended School											
No	69.5	1.24*** (1.08,1.44)	29	36	45	56	*69*	86	104	128	157
Yes (Ref)	30.5	1.00	23	29	37	45	*56*	70	86	106	130
Husband attended School											
No	50.0	1.18*** (1.04,1.34)	27	34	43	53	*66*	82	100	123	150
Yes (Ref)	50.0	1.00	23	29	37	45	*56*	70	86	106	130
Cluster Sanitation											
Toilet/Shared (Ref)	71.5	1.00	23	29	37	45	*56*	70	86	106	130
Pit/Latrine	17.2	1.29*** (1.09,1.53)	30	37	47	58	*72*	89	108	133	162
Open-Air/Other	11.3	1.08 (0.88,1.33)	25	32	40	49	*61*	75	92	113	139
SUDAN	N=8498										
Sex											
Male	51.5	1.20** (1.04,1.39)	3	16	88	5	*29*	154	9	54	258
Female (Ref)	48.5	1.00	2	13	74	4	*24*	132	8	45	224
Previous Birth Interval											
< 18 month	26.1	2.60*** (2.15,3.14)	6	33	172	11	*61*	283	20	110	429
18-23 month	18.5	1.20 (0.95,1.50)	3	16	87	5	*29*	154	9	54	257
24-35 month (Ref)	32.2	1.00	2	13	74	4	*24*	132	8	45	224
36+ month	23.2	0.67*** (0.52,0.86)	1	9	51	3	*17*	93	5	31	162
Previous Child Survived to Birth of Index Child											
Yes (Ref)	90.0	1.00	2	13	74	4	*24*	132	8	45	224
No	10.0	1.11 (0.9,1.37)	2	14	81	5	*27*	144	9	50	243

...(continued next page)

Table 5.6. Higher-order Births - Predicted Probability of death before Age 5 Years *(…………..Continued)*

		Model A3	Cluster-Effect								
		OR (95% C.I.)	- average			average			+ average		
Sudan	N=8498	Household-effect	-ve	av	+ve	-ve	*av*	+ve	-ve	av	+ve
Mother attended School											
No	70.4	1.49*** (1.17,1.90)	3	19	106	6	*36*	184	12	66	301
Yes (Ref)	29.6	1.00	2	13	74	4	*24*	132	8	45	224
Husband attended School											
No	42.6	1.43*** (1.16,1.77)	3	18	103	6	*35*	178	11	64	292
Yes (Ref)	57.4	1.00	2	13	74	4	*24*	132	8	45	224
Cluster Water Supply											
Gover- Piped (Ref)	31.7	1.00	2	13	74	4	*24*	132	8	45	224
Other	49.7	1.54** (1.09,2.19)	3	20	110	6	*37*	190	12	69	309
Well/Pumped	18.6	1.19 (0.89,1.60)	3	15	87	5	*29*	154	9	54	257
Yemen	N=12703										
Sex											
Male	52.0	1.13** (1.01,1.26)	10	22	46	18	*37*	77	30	63	128
Female (Ref)	48.0	1.00	9	19	41	16	*33*	69	27	56	115
Maternal age at birth											
< 18 yrs	4.3	1.08 (0.84,1.40)	10	21	44	17	*36*	74	29	61	123
18-19	6.9	0.92 (0.74,1.15)	8	18	38	14	*31*	64	25	52	106
20-24 (Ref)	26.4	1.00	9	19	41	16	*33*	69	27	56	115
25-29	26.5	0.86** (0.74,1.00)	8	17	35	13	*29*	60	23	49	100
30-34	18.7	0.84* (0.70,1.00)	8	16	34	13	*28*	58	23	48	98
35 +	17.3	0.94 (0.75,1.18)	8	18	38	15	*31*	65	25	53	109
Previous Birth Interval											
< 18 months	44.8	2.87*** (2.43,3.39)	25	53	109	43	*90*	175	74	147	271
18-23 months	17.5	1.62*** (1.33,1.99)	15	31	64	25	*53*	107	43	89	174
24-35 months (Ref)	20.8	1.00	9	19	41	16	*33*	69	27	56	115
36+ months	16.9	0.63*** (0.49,0.81)	6	12	26	10	*21*	44	17	36	75
Previous Child Survived to Birth of Index Child											
Yes (Ref)	85.4	1.00	9	19	41	16	*33*	69	27	56	115
No	14.6	1.64*** (1.43,1.88)	15	31	65	25	*53*	109	43	90	175
Birth Order X Previous Deaths											
B2-3 X 0 death (Ref)	32.3	1.00	9	19	41	16	*33*	69	27	56	115
B4-6 X 0 death	22.8	0.79*** (0.67,0.94)	7	15	32	12	*26*	55	21	45	93
B7+ X 0 death	5.7	0.75* (0.55,1.04)	7	15	31	12	*25*	53	20	43	89
B2-3 X 1 death	3.1	1.45*** (1.10,1.92)	13	28	58	22	*47*	97	39	80	158
B4-6 X 1 death	11.5	1.30*** (1.08,1.56)	12	25	52	20	*43*	88	35	72	144
B7+ X 1 death	6.3	1.23 (0.94,1.61)	11	24	50	19	*40*	84	33	69	137
B4-6 X 2+ deaths	5.7	1.02 (0.80,1.30)	9	20	42	16	*34*	70	28	58	117
B7+ X 2+ deaths	12.5	1.28** (1.04,1.58)	11	24	52	20	*42*	87	34	71	142
Area											
Urban (Ref)	23.4	1.00	9	19	41	16	*33*	69	27	56	115
Rural	76.6	1.27* (0.97,1.66)	11	24	51	20	*42*	86	34	71	141
Husband attended School											
No	75.7	1.23** (1.04,1.45)	11	23	49	19	*40*	83	33	68	137
Yes (Ref)	24.3	1.00	9	19	41	16	*33*	69	27	56	115
Clusters' Utility											
Electricity (Ref)	52.4	1.00	9	19	41	16	*33*	69	27	56	115
Kerosene	47.6	1.33*** (1.11,1.58)	12	25	53	21	*43*	90	35	74	147

Continuing with Table 5.6 (on page 195-196), one can examine the implication of the smaller random effect due to the cluster level. For the Sudan, a cluster with a negative average effect, at an average household-effect (i.e. household effect=0), the "actual" estimated probability of death, in slightly more than half that of an average cluster, while a cluster with a positive average effect will have an estimated probability close to double that of the average cluster. For Egypt, the same contrast shows with a negative average estimating about less than half the probability of death as that of an average cluster, and a positive average cluster will have a little less than double that of the average cluster, respectively. Similarly, for Yemen, a negative average cluster has about 60 per cent the estimated probability of death of an average cluster, but a positive average cluster could have about two-third more on the estimated probability of death of the average cluster, respectively.

At *average* cluster and household effects (figures in *italics* and bold), the highest estimates of mortality cross-countries are caused by birth intervals of less than 18 months (61 per 1000, Sudan; 144 per 1000, Egypt; and, 90 per 1000 in Yemen, respectively). Alternately, the lowest predicted mortality estimates are supportable by birth intervals exceeding 36 months (17 per 1000 in Sudan; 32 per 1000 in Egypt; and, 21 per 1000 in Yemen, respectively).

How can residual random effects be explained?

One possible set of factors not readily measurable by the survey relates to households' health behaviour regarding beliefs about certain diseases and appropriate forms of treatment. Retrospective birth histories miss-out in including information on birth-specific utilisation of health, hence immunisation, services-perhaps with second and third round DHS surveys that information will become available. Another plausible explanation derives from Das Gupta's (1990) work which suggested that some households are, in similar circumstance of resource constraints, more effective than others at taking care of their children-probably due to differences in ability to utilise such resources. Even though her models included key indicators to proxies like maternal-paternal education, and other socio-economic indices, but they remain imperfect in measuring parental efficacy or priorities in child care.

Speaking in terms of a frailer sub-group, with an increased force of mortality (e.g. epidemics, lack of immunisation,.., etc) frailer groups experience a quicker rate of decline of mortality even in favoured situations. Perhaps, in the cases of Sudan and

Yemen reduction in mortality rates at earlier ages (under 1) permit more children from the frailer sub-groups to survive to an older age (age 1-5). But this influx of frailer children serves as a brake or "counter-current" on reductions in mortality rates at older ages. Manton, Singer, and Woodbury (1992) suggest that the size of the influx will depend on the absolute magnitude of the reduction in mortality rates at younger ages (i.e. on the number of lives being saved in the frailer subgroup) and on the chances a frailer child has of reaching an older age. So, if the influx is small enough, one may still observe declining mortality rates, but if the influx is large enough, observed mortality rates may actually go up (Manton, Singer, and Woodbury, 1992).

The cluster level was added-in to provide a closer approximation to the true upper bound of the household effect, in addition to providing estimates of the magnitude and importance of the cluster effect. This is because if a level of design clustering is ignored, this could result in a substantial overstating of the true household-effect (Sastry, 1997). Where unexplained, the cluster-effects may not exactly "fit" the best classification of higher effects since a better definition could have been a "community" effect. Probably, adjustment for a higher-level in the hierarchy could have absorbed not just the cluster but also, the unexplainable household effects for Sudan and Yemen. Yet it proved rather difficult to distinguish a common definition or size of communities (or villages) between countries. What could be reassuring is that when Sastry (1997) used cluster rather than municipalities which were larger and more diverse than sampling clusters, it lead to no substantive differences in the results.

The idea of including a control for a measure of "intra-level" correlation deserves some clarification. The inclusion of the survival status of the immediately previous child not only serves as such a control but for the response of one (an older) individual in it. It has been shown that models (marginal or conditional) that condition on responses of other members of the cluster lead to downward biases in the estimated effects of the other variables (Rosner, 1984; Glynn and Rosner, 1994; and, Neuhaus and Jewell, 1990). Cesar, Palloni, and Rafalimanana (1997) reviewed alternative models and procedures in the analysis of child mortality with clustered data. Their simulations show that although, indeed, some of the estimated coefficients are attenuated, the biases are modest and, at any rate, smaller than those that are obtained if nothing is done to address intra-cluster correlation.

Although, their recommendation is for the use of GEE methods, especially with models *not* controlling for the survival status of the previous child.

Another issue may stem from the specification of the distribution of the unmeasured effects; was the Gaussian distribution an appropriate assumption for the unmeasured household effects in the case of Sudan. Heckman and Singer (1982) selected a simple parametric family of distributions to describe the distribution of unmeasured (unmeasurable) effects to investigate the sensitivity of parameter estimates (fixed effects) to *ad hoc* choices for the distribution of unmeasured heterogeneity (Normal, logNormal, Gamma, non-parametric mixed distribution) using hazard models on duration data. They used a non-parametric maximum likelihood estimator (NPMLE), implemented using the EM algorithm, which was a very robust estimator of structural parameters in duration models with *general* distributions of unmeasurable heterogeneity. They concluded that some qualitative properties of the distribution of an unmeasured variable can be inferred from the oscillation properties of the density of the observed duration. Far too often as Trussell and Hammerslough (1983) argue and since analysts can never know the true functional form of the model, they are left in the position of picking from various alternatives on the basis of plausibility of the estimates. Moreover, Heckman and Singer (1982) argue an infusion is needed of theoretical and/or empirical information from sources external to a given data set for effective estimation of mixing distributions. Manton, Stallard, and Vaupel (1981) demonstrated that results were also sensitive to the functional form of the model that is assumed for the hazard function. Trussell and Hammerslough (1983) argue in order to get any results at all, one must impose a parametric form of the risk function, for example Weibull or Gompertz. Lastly, the sizeable household's random-effects are a clear sign of the familial-setting association in child survival. Cultural differences, income distribution, which could be skewed, extremes of poverty versus affluence are perhaps more crucial explanatory effects. Probably an insightful tool for understanding these associations is a longitudinal study rather than a cross-sectional one. Casterline (1983) asserts that the interaction between characteristics measured at differing levels of aggregation, in particular community and individual characteristics. would provide a stimulus for further investigation, which he adds will typically mean a search for omitted variables. Yet the fact remains that these associations remain best captured by previous mortality measures until further detailed good-quality data are collected.

CHAPTER 6

COMPARING DIFFERENTIALS OF CHILD SURVIVAL IN THE THREE SETTINGS

6.1 Introduction

In the previous chapters, the relative importance of child survival strategies was investigated through the use of data from the PAP-CHILD surveys of Egypt, Sudan and Yemen. Using model-based analyses, a number of multivariate relations of bio-demographic and socio-economic factors and child survival were discussed. Net of models deployed, a number of issues emerge from these comparisons. This chapter is a repository of methodological and conceptual gains made, for individual countries, and crossing experiences between countries. Taken overall, results are remarkably similar to earlier investigations using WFS and DHS-based studies, suggesting unchanging relations overtime. Analysis using cross-sectional sample-survey data can only detect unmeasured effects, and at best, partially explain their nature. A potentially rewarding area for future policy-related research is probably investment in fair quality community data to better address such effects.

The aims of this chapter are two-fold. Firstly, to present key communalities and contrasts in child survival experiences in the three countries. And secondly, to assess the impact of averting exposure to higher risks in improving child survival in the three countries.

A few technical notes are worth starting with:

1. Given that multiple comparisons are present, a choice was made to begin the analysis deploying the survey logistic regression. The survey logistic model is a marginal model where the survey-design effects are adjusted, using sampling weights if applicable, in order to obtain the correct point estimates for effects, and the information on clustering and stratification to obtain the correct standard errors for point estimates, respectively. Even when samples were self-weighted, the correction has improved on the estimation of the standard errors and hence corrected for any chances of effects over-estimation[8].

2. The second model is the Cox model, which has the added advantages in incorporating time-varying effects and ameliorating any costs due to excluding recent births usually censored in survival times by the survey time. The Cox model produces hazard ratios (approximate relative risks) rather than odds ratios. To improve on the comparison of the Cox model results to those of the survey logistic regression, odds ratios of the latter type models were approximated to yield relative risks (Hogue, Gaylor, and Schulz, 1983; Boerma and Bicego, 1992). Appendix I (page 252) provides the array of the survey-design adjusted logistic model, the Cox model and the multi-level logistic model, respectively, with the purpose of organising the information for the reader.

3. The third model is the multilevel logistic, which allows adjustment for two hierarchical structures present in the data set, namely births to mothers, and mothers or households to geographical clusters. In these models, clusters' contextual attributes are in-effect introduced to better-describe the sample area- characteristics and, if possible, to reduce the influence of unmeasured effects. These were obtained by collapsing household-specific information on electricity supply, sanitation and water supply at the cluster level. It is important to mention that multilevel logistic estimates *without* the cluster-

[8] Using STATA svylogit command

characteristics effects added are close to identical to those produced by the survey-design adjusted logistic model.

Impressively, results have been consistent across differing models of analysis. Rather than only applying the Cox model to the same sample of births used for the logistic models (i.e. singleton births born in the period 5-15 years before the survey) a choice was made to extend findings through the inclusion of the more recent births which served to i) reassert fixed associations , ii) reflect attenuation in relations with time, iii) capture period changes associated with the more recent times before the survey and iv) deliver the time-varying effects intended.

With no distinction, handling of ties in failure times by the Cox model using Breslow (1974) or Efron (1977) approximations yielded close parameter estimates; due in part to the presence of independent censoring by the time of the survey. Hertz-Picciotto and Rockhill (1997) state that the effect of independent censoring would be to decrease the sample sizes of later risk sets, but it could also decrease the number of ties. If censoring were light and tend to occur later in the study, the impact on the bias from tie-handling methods would be small (Hertz-Picciotto and Rockhill, 1997, p.1155). Hence, the results retained were those produced using Breslow (1974) approximation which allows for sampling weights necessary in the case of Yemen's non-self weighted sample.

Section 6.2 addresses the first objective, a "cross-country" comparison of child survival correlates using a fixed set of multivariate relations, also reflective of subtle methodological gains. Section 6.3 deploys the epidemiological measure, population attributable fraction, to summarise the percentage reductions in mortality rates if the extra risk factors or groups were averted. Performed post the estimation of the survey-design adjusted logistic regression, the generalised equation gives the summary attributable fraction for all the factors combined for key policy recommendation. In Section 6.4 the chapter concludes by delivering simple descriptions and interpretations away from the methodological complexities, pointing out key gains where necessary. Generally, models compare well and where point estimates differ, the ranges of the 95 per cent confidence interval affirm consistency and overlap.

6.2 Contrasting Three Countries

From the previous section, one can fairly assert that key correlations of child survival emerge regardless of the methodology used. The purpose of this section is to bring the three-country findings to a closer examination. For practical purposes, the tabular presentation concentrates on the common fixed-effects of the survey logistic model, the added time-varying effects captured by the Cox model and further, the added multi-level fixed (cluster-characteristics) and random effects, respectively. Tables 6.2.1A-B and 6.2.2A-B show results of cross-countries comparisons of the differentials of under-5 mortality of first births and higher-order births, respectively.

6.2.1 *First births*

Before interpreting the comparison of the three countries, it is important to describe the entries of Table 6.2.1A (page 204). The first column describes the correlate followed by two columns per country to describe the distribution of the correlate for the birth cohorts concerned and the parameter estimates from the model used. The first correlate to consider in Table 6.2.1A is gender - male first births have at least one third extra risk of death before age five compared to that of female first births firmly in the case of Sudan and Yemen, but not in Egypt. These estimates of excessive risk are supportive if not consequential to the levels of under-reporting of female deaths detected by the data quality checks in the two countries concerned.

One in three first births in the cases of Sudan and Yemen were to mothers aged less than age 18 at the time of birth compared to about one in five in the case of Egypt. Yet the differential, in the multivariate relation, remains significant only for Egypt strongly characterising first births with maternal age of less than 18 with one and half times the risk of death before age five compared to those to mothers aged 20-24 at first birth. Rural Egypt bears the only significant "area of residence" differential in the three settings, where first births resident in rural areas with a significant rise in risks of about 57 per cent extra risk compared to their counter parts in urban areas. Similarly, Egyptian first births to mothers with no schooling show 44 per cent excess risk of death before age five compared to those to mothers with some schooling years; whilst not much difference can be found in the cases of Sudan and Yemen.

Table 6.2.1A: Cross-country Comparison of Under-5 mortality Analysis for First-Births

Correlates	N=3326	Egypt	N=1646	Sudan	N=2391	Yemen
SvyLogit Model	(%)	OR (95% C.I.)	(%)	OR (95% C.I.)	(%)	OR (95% C.I.)
Sex						
Male	52.7	1.14 (0.93,1.41)	52.9	1.38** (1.00,1.9)	51.0	1.34** (1.07,1.69)
Female (Ref)	47.3	1.00	47.1	1.00	49.0	1.00
Mother's age at birth						
< 18 years	22	1.51*** (1.15,1.97)	33.2	1.28 (0.89,1.83)	33.3	1.30* (0.99,1.70)
18-19 years	20.5	0.88 (0.65,1.20)	19.8	1.16 (0.74,1.81)	19.5	0.95 (0.67,1.35)
20-24 (Ref)	37.6	1.00	32.2	1.00	31.6	1.00
25-29	15.7	0.59*** (0.40,0.88)	11.2	0.78 (0.42,1.47)	9.7	0.74 (0.48,1.14)
30-34	3.2	1.19 (0.65,2.18)	3.0	0.52 (0.16,1.73)	4.2	1.42 (0.86,2.35)
35 +	1.0	1.13 (0.33,3.84)	0.6	0.87 (0.09,8.22)	1.7	0.80 (0.24,2.65)
Area						
Urban (Ref)	39.5	1.00	36.5	1.00	22.7	1.00
Rural	60.5	1.57*** (1.18,2.10)	63.5	1.24 (0.85,1.81)	77.3	1.08 (0.73,1.61)
Mother attended School						
No	54.7	1.44** (1.08,1.91)	51.3	0.97 (0.65,1.44)	85.5	1.52 (0.89,2.58)
Yes (Ref)	45.3	1.00	48.7	1.00	14.5	1.00
Husband attended School						
No	28.0	1.13 (0.88,1.45)	41.3	2.09***(1.40,3.11)	74.3	1.08 (0.81,1.45)
Yes (Ref)	72.0	1.00	58.7	1.00	25.7	1.00
Husband in Agriculture						
No	36.0	1.07 (0.82,1.39)	67.4	1.00	60.9	1.00
Yes (Ref)	64.0	1.00	32.6	0.70* (0.48,1.02)	39.1	1.42*** (1.09,1.86)
Gains from the Cox Model						
		RR (95 % C.I.)		RR (95 % C.I.)		RR (95 % C.I.)
Years Before Survey						
"0-4"	34.2	0.63*** (0.50,0.80)	33.5	1.14 (0.86,1.52)	27.6	0.52*** (0.40,0.67)
"5-9" (Ref)	33.3	1.00	35.5	1.00	35.3	1.00
"10-14"	32.5	1.14 (0.95,1.38)	31.0	0.84 (0.64,1.11)	37.1	1.05 (0.87,1.27)
Status Subsequent Birth						
0 = None (Ref)	49.1	1.00	49.5	1.00	50.3	1.00
1 = Conception	25.3	2.52*** (1.92,3.32)	25.2	1.77*** (1.17,2.69)	24.3	0.92 (0.66,1.29)
2 = Birth	23.5	1.85** (1.06,3.23)	23.7	1.19 (0.58,2.45)	22.5	0.84 (0.47,1.51)
3 = Death	2.1	2.60* (0.98,6.85)	1.6	3.99*** (1.61,9.90)	2.9	1.17 (0.48,2.83)
Gains from the Multilevel Logistic Regression						
		MLOR (95 % C.I.)		MLOR (95 % C.I.)		MLOR (95 % C.I.)
Clusters' Utility						
Electricity (Ref)	96.8	1.00	32.2	1.00	50.3	1.00
None	3.2	0.87 (0.48,1.60)	67.8	1.36 (0.84,2.22)	49.7	1.11 (0.80,1.54)
Clusters' Sanitation						
Toilet (Ref)	75.2	1.00	4.5	1.00	16.2	1.00
Pit/Latrine	15.1	1.71*** (1.29,2.25)	62.2	0.47* (0.20,1.10)	42.0	2.05** (1.18,3.54)
Open-Air/Other	9.7	1.12 (0.78,1.61)	33.3	0.48** (0.23,1.00)	41.8	2.10** (1.14,3.85)
Clusters' Water Supply						
Piped (Ref)	80.7	1.00	32.7	1.00	38.6	1.00
Well/Pumped	19.3	1.25 (0.96,1.64)	19.7	0.85 (0.48,1.50)	43.3	0.99 (0.68,1.44)
Other			47.6	1.18 (0.73,1.91)	8.1	1.03 (0.66,1.59)
	100.0		100.0		100.0	
Cluster-effect (s.e.)		0.07 (0.08)		0.05 (0.12)		0.16* (0.09)
"Intra-cluster" Correlation		0.021		0.02		0.049

Yet, paternal schooling in the case of Sudan, has the over riding effect over maternal schooling benefits, where the lack of husbands schooling more than doubles the risk of death before age five for first births. Whereas in neither Egypt nor Yemen do effects due to paternal schooling on survival chances of first births hold. Yemeni first births whose fathers work in agriculture have significantly two-fifths more risk of death before age five as that of their counterparts. There is some marginal evidence in Sudan that first births born to households were the husbands' work is in agriculture might enjoy lesser risk than their counterparts.

Turning to the gains of the Cox model analysis, period effects estimates indicate an improving situation of the recent period compared to earlier periods, except in Sudan where signs of improvement with time are bleak.

The time-varying effects of subsequent birth (conception/ birth/ death) show similar immediate risk periods for the first births in the case of Egypt and Sudan but not Yemen.

Gains from the "fixed-effects" contextual correlates in the multi-level model, show residence in cluster settings with access to toilet-sanitation and piped water supplies significantly promotes survival chances for first births in the cases of Egypt and Yemen.

With first births, and by data structure, *one* plausible random effect is that captured at the cluster level. Given the resultant multivariate relation, Yemen is the only country in the group to sustain a marginally significant variance component of the unmeasured cluster effects. Yet, if one considers the estimated "intra-cluster" correlation coefficient, the coefficient is rather small (0.049). Rather than re-displaying the results of the same models shown by Table 6.2.1A with and the "intra-country" split of the variance component at the cluster-level, the choice was made to highlight only the random part-shown by Table 6.2.1B (on the next page). Crucially, cross-countries, the variance components as split by region remains insignificant. Yet the components reflect their size; the highest magnitude belongs to Urban Upper Egypt, Kordofan in Sudan and the North & West region in Yemen, respectively.

Table 6.2.1B: Characteristics of Random-Effects in the Analysis of Under-5 mortality Analysis of First Births

Variance Component Cluster-effect(s.e.) "Intra-cluster" Correlation					
Egypt		Sudan		Yemen	
Urban Gover	0.0 (0.0) 0.00	Khartoum	0.0 (0.0) 0.00	North & West	0.18* (0.09) 0.052
Urban Lower	0.0 (0.0) 0.00	Eastern	0.12 (0.33) 0.035	South & East	0.05 (0.21) 0.015
Rural Lower	0.03 (0.12) 0.009	Central	0.14 (0.23) 0.041		
Urban Upper	0.67 (0.53) 0.169	Darfur	0.01 (0.24) 0.003		
Rural Upper	0.10 (0.13) 0.029	Kordofan	0.23 (0.37) 0.065		
		Northern	0.12 (0.59) 0.04		

*** Sig. at 1%, ** Sig. at 5%,* Sig. at 10%,

6.2.2 *Higher-order Births*

The results of fitting the models for higher order births to the data from the three PAP-CHILD surveys will now be examined. For practical purposes, the tabular results are presented in a non-conventional form, highlighting the common fixed-effects of the survey logistic model, the added time-varying effects captured by the Cox model and further, the added multi-level fixed (cluster-characteristics) and random effects. Tables 6.2.2A and 6.2.2B show the cross-countries comparative results of under-five mortality of higher-order births, and the characteristics of random-effects of under-five mortality of higher-order births, respectively. The first column describes the correlate followed by two columns per country to describe the distribution of the correlate for the birth cohorts concerned, the parameter estimates from the model and the corresponding 95% confidence intervals, respectively, shown in Table 6.2.2A (on pages 208-209).

For birth orders two and above the array of factors carry over from those seen earlier with first births with the addition of three key bio-demographic effects, the effect of the preceding birth interval, the effect of the survival status of the immediately previous child and the interaction effects of the birth order with older siblings mortality prior to the birth of the index child.

The innate survival advantage for female births should fizzle-out, especially since mortality to age five is being considered. The net survival advantage for females is weak which is perhaps more normative behaviour of the differential. Yet the estimate in the case of Sudan persists with a significant one-fifth increase in the odds of death before age five for male later births.

The models bear a strong suggestion that survival chances for children improve slowly with increasing age of mother beyond age 18 up to age 35. In the case of Egypt, and compared with children born to 20-24-year-old mothers, the overall average deviations in the odds ratios suggests a 44 per cent net increase for births to 18-19-year-old, and a net decrease of 19 per cent for those born to 25-29 and 30-34-year-old mothers respectively. However, second and higher births to very young mothers are rare, and, few of the individual parameter estimates are statistically significantly different from the reference group of 20-24-years-old-mothers.

The length of the preceding birth interval dominates as the most influential effect across countries and methods. The percentage of births with a preceding birth intervals of less than 18 months in Egypt is 24 per cent, almost half Yemen's 45 per cent, yet the gradient of risk is the same with an odds ratio estimate of 2.80: 1.0 compared to the baseline birth interval of 24-35 month (p-value <0.001). Conversely, the percentage of births with a preceding birth interval of 36+ months in Yemen is 17 per cent, which is close to half that of Egypt's 30 per cent, yet the beneficial effects are of the same magnitude; roughly a reduction in risks of about 42 per cent. Considering the two countries levels of contraceptive use, this result could be worrying. The situation in Sudan keeps middle ground, where the shift from shorter to longer birth intervals is taking place with lower risks, lower benefits in both directions. A consistent survival advantage is associated with birth intervals in excess of three years. Long intervals of three years and more could dispel, at the very least, one-third of mortality risks before age five for later births following.

Next to consider is the association of child survival with previous mortality among its older siblings. These measures draw heavily on the precision of the date of occurrence of a child death for the preceding births. The motivation behind these parity-based measures of the familial-history of child losses is to observe whether the risks of death would increase monotonically with more counts of older siblings deaths. This proved to be almost the case in the estimates for Egypt, but not Sudan and Yemen.

Table 6.2.2A: Cross-country Comparison of Under-5 mortality Analysis for Higher-Order Births

Correlates	N=13263	Egypt	N=8498	Sudan	N=12703	Yemen
SvyLogit Model	(%)	OR (95% C.I.)	(%)	OR (95% C.I.)	(%)	OR (95% C.I.)
Sex						
Male	51.2	0.94 (0.84,1.06)	51.6	1.19***(1.05,1.36)	52.0	1.12* (1.00,1.27)
Female (Ref)	48.8	1.00	48.5	1.00	48.0	1.00
Mother's age at birth						
< 18 years	2.7	1.44*** (1.09,1.90)	3.6	1.25 (0.88,1.77)	4.3	1.10 (0.85,1.41)
18-19 years	5.1	1.03 (0.81,1.32)	5.9	0.88 (0.65,1.19)	6.9	0.91 (0.72,1.16)
20-24 (Ref)	27.0	1.00	25.7	1.00	26.4	1.00
25-29	29.7	0.89 (0.77,1.03)	27.4	0.99 (0.81,1.20)	26.5	0.88* (0.77,1.01)
30-34	21.4	0.81** (0.68,0.98)	21.0	1.04 (0.84,1.29)	18.7	0.85* (0.72,1.01)
35 +	14.0	0.91 (0.75,1.11)	16.3	1.19 (0.91,1.56)	17.3	0.96 (0.77,1.18)
Previous Birth Interval						
< 18 month	24.0	2.80***(2.44,3.22)	26.1	2.43*** 2.03,2.90)	44.8	2.80*** (2.35,3.34)
18-23 month	17.4	1.50***(1.28,1.75)	18.5	1.19* (0.98,1.44)	17.5	1.59*** (1.29,1.96)
24-35 month (Ref)	28.7	1.00	32.2	1.00	20.8	1.00
36+ month	29.8	0.57***(0.48,0.66)	23.2	0.69***(0.55,0.87)	16.9	0.58*** (0.45,0.75)
Birth Order X Previous Deaths						
B2-3 X 0 death (Ref)	39.8	1.00	33.1	1.00	32.3	1.00
B4-6 X 0 death	20.9	1.07 (0.91,1.26)	25.9	0.87 (0.71,1.06)	22.8	0.76*** (0.64,0.90)
B7+ X 0 death	3.3	1.54***(1.11,2.14)	9.7	0.81 (0.57,1.15)	5.7	0.69** (0.49,0.97)
B2-3 X 1 death	3.4	1.81*** (1.4,2.35)	2.5	1.66** (1.10,2.5)	3.1	1.32* (0.98,1.77)
B4-6 X 1 death	12.0	1.79*** (1.5,2.15)	9.8	1.35** (1.04,1.76)	11.5	1.27** (1.05,1.52)
B7+ X 1 death	4.6	1.55***(1.18,2.04)	7.1	1.08 (0.78,1.5)	6.3	1.21* (0.97,1.52)
B4-6 X 2+ deaths	5.4	2.11***(1.67,2.65)	3.4	1.31 (0.89,1.93)	5.7	1.03 (0.79,1.33)
B7+ X 2+ deaths	10.6	1.96*** (1.60,2.39)	8.6	1.24 (0.90,1.72)	12.5	1.31** (1.04,1.64)
Previous Child Survived to Birth of Index Child						
Yes (Ref)	85.9	1.00	90.0	1.00	85.4	1.00
No	14.1	1.50***(1.31,1.71)	10.0	1.68***(1.42,1.99)	14.6	1.89*** (1.62,2.21)
Area						
Urban (Ref)	34.2	1.00	33.4	1.00	23.4	1.00
Rural	65.9	1.26***(1.08,1.47)	66.6	0.96 (0.81,1.15)	76.6	1.06 (0.87,1.30)
Mother attended School						
No	69.5	1.26***(1.09,1.47)	70.4	1.39***(1.12,1.72)	94.1	1.27 (0.93,1.73)
Yes (Ref)	30.5	1.00	29.6	1.00	5.9	1.00
Husband attended School						
No	63.7	1.17***(1.04,1.32)	40.4	1.37***(1.12,1.67)	68.0	1.24*** (1.07,1.45)
Yes (Ref)	36.3	1.00	59.6	1.00	32.0	1.00
Husband in Agriculture						
No	50.0	0.96 (0.85,1.09)	42.6	1.00	75.7	1.00
Yes (Ref)	50.0	1.00	57.4	1.06 (0.91,1.24)	24.3	1.12 (0.98,1.28)
Gains from the Cox Model						
Years Before Survey		RR (95 % C.I.)		RR (95 % C.I.)		RR (95 % C.I.)
"0-4"	34.5	0.70***(0.62,0.78)	32.9	0.98 (0.86, 1.13)	33.4	0.69*** (0.61, 0.77)
"5-9" (Ref)	33.7	1.00	37.4	1.00	38.5	1.00
"10-14"	31.8	1.05 (0.96,1.15)	30.4	0.96 (0.85, 1.08)	28.1	1.17*** (1.06, 1.28)
Extra Sibling Deaths						
None (Ref)	97.9	1.00	97.3	1.00	97.5	1.00
1 Extra deaths	2.1	3.43***(2.72,4.33)	2.7	3.57***(2.80, 4.57)	2.5	2.60*** (2.07, 3.27)
Status Subsequent Birth						
0 = None (Ref)	60.4	1.00	54.4	1.00	54.3	1.00
1 = Conception	19.8	2.35*** (2.04,2.70)	22.6	1.77***(1.48,2.12)	22.8	1.04 (0.91, 1.19)
2 = Birth	18.0	2.46***(1.93,3.15)	21.2	1.81*** (1.41,2.32)	21.0	0.72*** (0.58, 0.89)
3 = Death	1.8	2.62***(1.71,4.01)	1.8	3.48***(2.42,5.00)	1.9	1.18 (0.84, 1.65)

Table 6.2.2A: Cross-country Comparison of Under-5 mortality Analysis for Higher-Order Births (..continued)

Correlates	N=13263	Egypt	N=8498	Sudan	N=12703	Yemen
Gains from the Multilevel Logistic Regression						
		MLOR(95 % C.I.)		MLOR(95 % C.I.)		MLOR (95 % C.I.)
Clusters' Utility						
Electricity (Ref)	96.6	1.00	30.1	1.00	52.4	1.00
None	3.4	0.97 (0.66,1.43)	69.9	0.91 (0.68,1.23)	47.6	1.33*** (1.11,1.58)
Clusters' Sanitation						
Toilet (Ref)	71.6	1.00	4.7	1.00	16.9	1.00
Pit/Latrine	17.2	1.29***(1.09,1.53)	63.2	1.74* (0.93,3.27)	41.6	1.21 (0.91,1.6)
Open-Air/Other	11.2	1.08 (0.88,1.33)	32.1	1.71* (0.97,3.03)	41.5	1.30 (0.95,1.78)
Clusters' Water Supply						
Gover-Piped (Ref)	79.0	1.00	31.7	1.00	40.4	1.00
Well/Pumped	21.0	1.03 (0.87,1.21)	49.7	1.55** (1.09,2.20)	40.9	0.99 (0.81,1.21)
Other			18.6	1.19 (0.89,1.60)	18.7	0.97 (0.77,1.23)
	100.0		100.0		100.0	
Cluster-effect (s.e.)		0.12*** (0.03)		0.10** (0.05)		0.08*** (0.03)
"Intra-cluster" Correlation		0.035		0.024		0.023
Household-effect		0.01 (0.06)		0.81*** (0.12)		0.15*** (0.05)
"Intra-household" Correlation		0.038		0.217		0.065

*** Sig. at 0.1%, ** Sig. at 5%,* Sig. at 10%,

By and large, events of deaths of older siblings are systematic and clear indicators of familial settings of higher exposure to child loss; more so in Egypt in comparison to the Sudan and Yemen.

Not surprisingly, there is a clear and strong association between the survival status of the immediately preceding child and that of the index child. In the case of Sudan, the odds of death before age five are two-thirds higher when later births are born after the death of the immediately preceding child. The indicator of excess risk for Yemeni later births shows close to double the risk, whilst in the case of Egypt, excess risks are lower risk estimated as 50 per cent. It is also worth mentioning that effects of other bio-demographic factors such as sex and maternal age at birth attenuate slightly once the familial history of child losses are controlled for.

For the situation of considerable prevailing child mortality levels, as in Sudan and Yemen, the death of the immediately previous sibling is a stronger timely correlate for the survival chances of the index child perhaps slightly weaker for Egypt. Whilst in Egypt, with lower prevailing mortality levels, older sibling mortality captures "screen" familial inter-dependencies of survival, such as health-conditions or parenting practices, within the household.

Given the socio-economic differentials by area of residence, rural Egypt has the only significant disadvantage with an average estimate of 26 per cent increased risks of death before age five for higher order birth born in rural Egypt. Lack of maternal schooling shows the most sizeable effect in Sudan where the odds of death increase by 39 per cent compared to Egypt's 26 per cent, both countries with two-thirds of later births born to mothers with no schooling. Probably in Egypt the burden is circumvented by wider-spread and better implemented maternal and child health / family planning activities in operation.

Interesting enough, two-fifths of later births in the case of Sudan belong to mothers' whose husbands have no schooling compared to two-thirds in Egypt and Yemen yet higher mortality risk is found in Sudan. The estimated increase in the odds of death is 37 per cent in the case of Sudan, followed by Yemen's 24 per cent and Egypt's 17 per cent, respectively. This could be due to a complex economic differential arising from the association of education with levels of income and living standards.

Turning to the first gain from the Cox model, period-effects show an overwhelming alignment of improving conditions closer to the survey date. The trend shows improvements by lower risks in Egypt and Yemen, with no change for the Sudan; a trend confirmed also with first births analysis. Compared to the baseline period ("5-9" years before the survey), the recent period 0-4 years before the survey, Yemen and Egypt repeat estimates of a one-third drop in mortality risks, while for the Sudan the trend is showing little change if any at all.

The indicator of "extra siblings death" is the first of the two time-varying variable applicable only to later births to capture the extra risk triggered by the "new event" of death of an older sibling, who was alive at the birth of the index birth. A rare event occurring to less than three per cent of later births in these settings, yet triggers more than a three-fold excess mortality risks for index later births in Egypt and Sudan, respectively. In the case of Yemen, the extra risk premptied by an extra death of an older sibling is two and half times that of the state of no change in the time-varying correlate.

The second time-varying covariate is the indicator of the status of the survival status of the subsequent pregnancy. The baseline state considered is that of no subsequent conception. About one-fifth of higher order births exit the exposure time with a subsequent conception taking place; the average significant excess risk parameter estimate corresponds to a relative risk of 2.35 : 1 in Egypt and 1.77 : 1 in Sudan (both p-values < 0.001), but remains non-changing in the case of Yemen. Another one-fifth of later births exit their exposure time with a subsequent birth taking place; similarly, the excess risks are slightly more than before in the cases of Egypt and Sudan, respectively, but reverse direction to show significantly reduced risks of about 28 per cent in the case of Yemen. The remaining tiny percentage of later births (less than two per cent) exit the exposure period with a subsequent child's death; these bear the highest estimates of excess risk considering the two states previous. The estimated increase in risk of death before age five is two and half times, and three and half times, that of no conception, in the cases of Egypt and Sudan, respectively. The estimation for Yemen persists with a lack of change in mortality risks with the death of a subsequent birth.

Further "fixed-effect" additions offered by the multi-level models (shown by the continued section of Table 6.2.2A, page 209) include the clusters' "contextual" variables describing sanitation, type of water supply and access to electricity supply. Clusters with better facilities naturally, indicate better survival opportunities. In Yemen, children's' residence in clusters with no electricity evidently indicates their odds of death before age five could increase by about one-third compared to their counterparts resident in clusters with electricity. Residence in clusters lacking toilet-sanitation bears moderate and marginally significant extra risks in Sudan and Egypt for children under five. The safer the cluster's water supply the higher the returns for the health status of its residents – in Sudan, children's' residence in clusters with well/pumped water supply induces 55 per cent rise to their odds of death before age five compared to clusters with piped water supply.

The continued part of Table 6.2.2A (p.209) illustrates the estimates of random-effects influencing survival chances of later births. It is worth noting at this stage that both the unmeasured cluster-effect and household-effect were considerably reduced in size and significance with the multivariate relations shown in Table 6.2.2A.

The variance component σ^2_v of the cluster effect remains significantly different from zero for the three countries. The variability in magnitude varies from highest in Egypt (0.12), lower in Sudan (0.10) and lowest in Yemen (0.08). Judging these effects in terms of the corresponding "intra-cluster" correlation coefficients, the often-ignored correlation would seem rather small (Egypt, ρ_v =0.035, Sudan, ρ_v =0.024 and Yemen, ρ_v =0.023).

Considering the variance component σ^2_u of the household effect, the parameter reduces in the multivariate association close to zero in the case of Egypt (0.01), yet prevails significantly different from zero in the cases of Sudan (0.81) and Yemen (0.15). The "intra-household" correlation coefficient is Egypt (ρ_u = 0.038) is almost a by-product of the higher-hierarchical "intra-cluster" correlation. But for Sudan (ρ_u = 0.217) the "intra-household" correlation coefficient is more than five times that estimated for Egypt and more than three times that of estimated for Yemen (ρ_u = 0.065), respectively.

An alternative way to understanding unmeasured effects was to represent them regionally within countries. In Table 6.2.2B (on the next page), results illustrate five variance-component estimates of the random-effect at the cluster level for Egypt, six for Sudan and two for Yemen, respectively. Variance-component splits are also plausible for the subordinate household-level, and these were obtainable only for Yemen. In the cases of Sudan and Egypt, the multilevel logistic model could not offer convergent estimates with the 2nd order PQL (even when the iterative process runs in excess of 10,000 iterations)– two plausible causes are: the smaller number of births per household and the lower variability of the response at that level, due to lower child mortality levels.

In the case of Egypt, there are 5-regional variance-component estimates at the cluster level. Only Urban Governates (Cairo & Alexandria) and Rural Upper Egypt have sizeable and significant estimates, having "intra-cluster" correlations ρ_v= 0.081 and ρ_v = 0.041, respectively.

This is an interesting feature of the analysis since the heterogeneity expected with-in the Urban Governates might not be readily similar to that of Rural Upper Governates. Feasibly, "true" heterogeneity in socio-economic and environmental conditions exists "within" both regions; both densely populated, with varying levels of access to population services.

In Sudan, the variance-components at the cluster-level are reduced to zero by the multivariate relation in the governates of Khartoum and Kordofan, but since the household-effect is substantial, the "intra-household" correlation holds at ρ_u =0.188. A similar situation occurs in the Central governate (ρ_u = 0.192). But for the Northern, Eastern and Darfur governates the cluster-effects are sizeable yet insignificant leaving a high "intra-household" correlation ρ_u of 0.307, 0.237 and 0.229, respectively. Perhaps more serious is the intra-cluster correlation of Darfur (ρ_v =0.228), since the variance-component estimate at the cluster level is marginally significant.

Table 6.2.2B: Characteristics of Random-Effects in the Analysis of Under-5 mortality of Higher-Order Births

Variance Component Cluster-effect (s.e.)

Egypt		Sudan		Yemen	
Urban Gover	0.28** (0.14)	Khartoum	0.0 (0.0)	North & West	0.05* (0.02)
Urban Lower	0.11 (0.12)	Eastern	0.26 (0.18)	South & East	0.27** (0.11)
Rural Lower	0.04 (0.04)	Central	0.02 (0.07)		
Urban Upper	0.08 (0.10)	Darfur	0.22* (0.13)		
Rural Upper	0.16*** (0.05)	Kordofan	0.0 (0.0)		
		Northern	0.70 (0.49)		

Variance Component Household-effect (s.e.)

Egypt		Sudan		Yemen	
	0.02 (0.06)		0.76*** (0.11)	North & West	0.17** (0.05)
				South & East	0.11 (0.08)

"Intra-Cluster" Correlation
"Intra-Household" Correlation

Egypt		Sudan		Yemen	
Urban Gover	0.078	Khartoum	0.000	North & West	0.014
Household	0.084	Household	0.188	Household	0.063
Urban Lower	0.032	Eastern	0.060	South & East	0.076
Household	0.038	Household	0.237	Household	0.106
Rural Lower	0.012	Central	0.005		
Household	0.018	Household	0.192		
Urban Upper	0.024	Darfur	0.052		
Household	0.029	Household	0.229		
Rural Upper	0.052	Kordofan	0.000		
Household	0.052	Household	0.188		
		Northern	0.147		
		Household	0.307		

*** Sig. at 0.1%, ** Sig. at 5%,* Sig. at 10%,

As mentioned earlier, variance-components splits where possible in the case of Yemen, both at the cluster and household level. A striking finding, at the cluster level, is that the larger and more significant of the resultant variance components belong to the "South & East" (contrary to the finding encountered with first births analysis). Judging by that and the size of "intra-cluster" correlation, all being equal, the amount of heterogeneity in children's survival chances, at the cluster level, estimated for the "South & East" region is almost five times that estimated for the "North & West" region of Yemen. This finding perhaps relates most to the cluster-level provisions promotive to children survival. Those are either available to every cluster or to none in the case of the "North & West", hence indicating more homogeneity of children survival within clusters. Or, the two regions have comparable levels of promotive provisions at the cluster-level, maybe with a variable degree of accessibility and equality of distribution in the "South & East" region, and hence more heterogeneity in children survival. Quite possibly, the two scenarios could together apply, and can be supported by the description of the public health situation in Southern Yemen (Segall and Williams (1983).

Lastly, the multivariate observed associations of the final multi-level model seem to fully explain household-unmeasured effects on chances of survival in the case of "South & East" region. This time, the "North & West" region remains with a substantial variance-component estimate at the household level (σ_u=0.17) with an "intra-household" correlation (ρ_u =0.063), respectively. Perhaps, the unmeasured effects captured relate more to latent effects (parental practices) and less to the not so adequately measured living conditions within the household. This perhaps directly relates to the finding of Myntti's (1993), who observed that despite the uniformly unhealthy environment, a minority of the families carried most of the burden of child illness and death.

Having reviewed the comparability of extra risks between countries, one seeks to represent the degree of variability in mortality reductions attributable to individual and collective correlates, discussed in the following section.

6.3 Population Impact

One extra attempt offered by the thesis is a simple summary of how the prevailing levels of childhood mortality could benefit from percentage reductions if the extra risk effects quantified by the multivariate models are averted. One motivation stems from the work by Trussell and Pebley (1984). They were interested but were unable to estimate the *combined* effect of changing age, parity and birth spacing simultaneously because at the time no studies reported results when all three factors are include in the same multivariate model.

Tables 6.3.1 and 6.3.2 illustrate results of population-attributable fractions (AF) calculated post the estimation of the survey-design adjusted logistic regression. The assumption is that given the level of childhood mortality at the advantaged reference groups, what would be the combined gain in averting all higher risk behaviour or conditions shown by the covariates. Estimating attributable fractions in this way allows for cofounders to be taken into account and allows estimation of a summary attributable fraction for a set of exposures (Brady, 1998).

Starting with Table 6.3.1 (page 216), and in the case of Egypt, close to a fifth of under-5 mortality is attributable to residence in Rural Upper Egypt, close to a fifth is attributable to lack of maternal schooling, and close to a tenth is attributable to teenage mothers pregnancies. Altogether, if increasing risk exposures identified in the multivariate survey-design adjusted logistic model are eliminated (both significant and non significant ones) under-5 mortality of firstborns could be halved in Egypt (54.4 per cent).

In Sudan, a quarter of first births mortality before age 5 can be attributable to the economic disadvantage associated with their fathers' lack of schooling. What is perhaps estimated as excess mortality attributable to a gender-bias is an artefact of the serious level of under-reporting of dead female first births. Though small in impact, 7.4 per cent of first births mortality before age five is attributable to teenage maternal ages. Overall the model-based relations are promising, despite the under-pinning unexplained effects, showing under-5 mortality could be reduced by 44.3 per cent, more in closing the gaps mitigated by socio-economic factors than others.

In the case of Yemen, outstandingly one-third of under-5 mortality is attributable to residence in the "North & West" region. Closely following that, the burden of maternal illiteracy contributes to one-fifth of under-5 mortality in Yemen. As seen earlier in the case of Sudan, a visible 10.9 per cent of mortality under-five could be attributed to sex-difference, which could be true if under-reporting of female deaths was not the case. Overall Yemeni first births stand to benefit a 60.6 per cent percentage reduction in under-5 mortality levels if effects recognised by the multivariate relation are averted.

Table 6.3.1: Cross-country Attributable Fraction (AF) of Under-5 mortality for First-Births

Correlates	N=3326 (%)	Egypt AF (s.e.)	N=1646 (%)	Sudan AF (s.e.)	N=2391 (%)	Yemen AF (s.e.)
Sex						
Male	52.7	0.064 (0.047)	52.9	*0.141 (0.072)*	51.0	*0.109 (0.046)*
Female (Ref)	47.3	0.000	47.1	0.000	49.0	0.000
Mother's age at birth						
< 18 years	22.0	*0.097 (0.036)*	33.2	0.074 (0.054)	33.3	0.057 (0.039)
18-19 years	20.5	-0.026 (.)	19.8	0.024 (0.039)	19.5	-0.008 (.)
20-24 (Ref)	37.6	0.000	32.2	0.000	31.6	0.000
25-29	15.7	*-0.04 (.)*	11.2	-0.019 (.)	9.7	-0.02 (.)
30-34	3.2	0.003 (0.006)	3.0	-0.012 (.)	4.2	0.011 (0.01)
35 +	1.0	0.001 (0.003)	0.6	-0.001 (.)	1.7	-0.008 (.)
Area						
Urban (Ref)	39.5	0.000	36.5	0.000	22.7	0.00
Rural	60.5	0.000 (0)	63.5	0.071 (0.114)	77.3	0.025 (0.114)
Mother attended School						
No	54.7	*0.183 (0.073)*	51.3	-0.017 (.)	85.5	0.187 (0.153)
Yes (Ref)	45.3	0.000	48.7	0.000	14.5	0.00
Husband attended School						
No	28.0	0.037 (0.053)	32.6	*0.251 (0.066)*	74.3	-0.005 (.)
Yes (Ref)	72.0	0.000	67.4	0.000	25.7	0.00
Husband in Agriculture						
No (Ref)	36.0	0.000	41.3	0.000	60.9	0.00
Yes	64.0	0.02 (0.044)	58.7	-0.129 (.)	39.1	*0.086 (0.033)*
Years Before Survey						
"0-4"						
"5-9"(Ref)	50.6	0.000	53.3	0.00	48.7	0.00
"10-14"	49.4	0.026 (0.017)	46.7	-0.081 (.)	51.3	0.031 (0.054)
Region						
Urban Gover (Ref)		0.000	Khartoum	0.000	South & East	0.00
Urban Lower		-0.009 (.)	Eastern	0.038 (0.033)	North &West	*0.325 (0.095)*
Rural Lower		*0.104 (0.047)*	Central	0.042 (0.057)		
Urban Upper		*0.033 (0.018)*	Darfur	0.062 (0.044)		
Rural Upper		*0.188 (0.043)*	Kordofan	0.016 (0.034)		
			Northern	0.016 (0.017)		
TOTAL		0.544 (0.082)		0.443 (0.119)		0.606 (0.093)

AF: Calculated from the Odds Ratios of the Survey-design Adjusted Model.
In Italics are the significant relations in the survey logistic models of Table 6.2.1A)

Turning to Table 6.3.2 (page 218), a similar scenario repeats itself with higher births orders. Considering a score estimate of greater than 0.1 (corresponding to about a 10 per cent excess mortality) as evidence of significant individual excess child mortality, cross-countries the predominance is with the effects of the length of short birth intervals. To that effect alone, close to a quarter of under-5 mortality is attributable in the case of Egypt and Sudan, and, close to two-fifths in the case of Yemen, respectively. Significant average gains at the population level do appear to be plausible through improved child spacing specifically when births at intervals of less than 18 months are avoided.

The information on survival outcomes of older siblings is separated into two components: the immediately previous birth and earlier births. For the preceding birth the population attributable fraction are generally fairly low and approach 0.1 only in the case of Yemen. For the earlier births only for Egypt is the *total additive* population attributable fraction exceeds 0.1 (equals 0.128). Further still, there are suggestions of unusual excess mortality associated with births of order two or more where "earlier" births had all survived to the birth of the index child in Egypt (0.019). Later births in lower mortality families, have an apparent survival advantage in Sudan and Yemen.

In the case of Egypt, a further one-fifth of under-5 mortality appears attributable to rural residence. The largest overall potential gains from universal schooling appear for Sudan with an impact score in excess of 0.186. The positive returns with extending fathers schooling efforts would perhaps leave moderate reductions (with a maximum gain of the order of 16 per cent in the case of Yemen and 15 per cent in the case of Sudan).

A surprising finding is that the regional differential shows zero attribution. With the region of residence, the question posed is how much is the excess child mortality at the population level compared with the hypothetical situation where every child experienced the net mortality risks of the best region in their country. In Sudan, the highest excess mortality is estimated for Darfur at 6 per cent compared to Khartoum's; surprisingly the common disparity of Upper Egypt as compared to the Urban governates fail to feature, while Lower Egypt show consistently lower mortality than those found in the best performing Urban governates. For Yemen, the familiar regional disparity between the "North & West" and "South & East" is close to non-existent. The extent of regional disparities for these countries surely requires further investigation in a separate study which can examine the differentials in health inputs by region and also brings to bear ecological information.

Table 6.3.2: Cross-country Attributable Fraction (AF) of Under-5 mortality for Higher Order Births

Correlates		N=13263 %	Egypt AF (s.e.)	N=8498 %	Sudan AF (s.e.)	N=12703 %	Yemen AF (s.e.)
Sex							
Male		51.2	-0.023 (.)	51.6	*0.072 (0.027)*	52.0	*0.045 (0.024)*
Female	(Ref)	48.8	0.000	48.5	0.000	48.0	0.000
Mother's age at birth							
< 18 years		2.7	*0.013 (0.006)*	3.6	0.009 (0.007)	4.3	0.002 (0.005)
18-19 years		5.1	0.001 (0.008)	5.9	-0.006 (.)	6.9	-0.006 (.)
20-24	(Ref)	27.0	0.000	25.7	0.000	26.4	0.000
25-29		29.7	-0.025 (.)	27.4	0.001 (0.02)	26.5	-0.03 (.)
30-34		21.4	-0.027 (.)	21.0	0.008 (0.018)	18.7	-0.026 (.)
35 +		14.0	-0.008 (.)	16.3	0.027 (0.019)	17.3	-0.009 (.)
Previous Birth Interval							
< 18 months		24.0	*0.255 (0.017)*	26.1	*0.23 (0.023)*	44.8	*0.376 (0.025)*
18-23 months		17.4	*0.056 (0.011)*	18.5	0.023 (0.014)	17.5	*0.056 (0.011)*
24-35 months	(Ref)	28.7	0.000	32.2	0.000	20.8	0.000
36+ month		29.8	*-0.083 (.)*	23.2	*-0.051 (.)*	16.9	*-0.035 (.)*
Birth Order X Previous Deaths							
B2-3 X 0 death	(Ref)	39.8	0.000	33.1	0.000	32.3	0.000
B4-6 X 0 death		20.9	0.008 (0.011)	25.9	-0.027 (.)	5.7	*-0.042 (.)*
B7+ X 0 death		3.3	*0.009 (0.004)*	9.7	-0.014 (.)	6.3	*-0.014 (.)*
B2-3 X 1 death		3.4	*0.022 (0.005)*	2.5	*0.012 (0.006)*	22.8	0.011 (0.005)
B4-6 X 1 death		4.6	*0.056 (0.009)*	9.8	*0.026 (0.012)*	3.1	*0.029 (0.009)*
B7+ X 1 death		5.4	*0.013 (0.004)*	7.1	0.006 (0.011)	5.7	0.008 (0.006)
B4-6 X 2+ deaths		12.0	*0.038 (0.007)*	3.4	0.008 (0.007)	11.5	0.006 (0.006)
B7+ X 2+ deaths		10.6	*0.046 (0.007)*	8.6	0.019 (0.014)	12.5	*0.033 (0.012)*
Previous Child Survived to Birth of Index Child							
Yes	(Ref)	85.9	0.000	90.0	0.000	85.4	0.000
No		14.1	*0.059 (0.011)*	10.0	*0.055 (0.01)*	14.6	*0.091 (0.012)*
Area of Residence							
Urban	(Ref)	34.2	0.000	33.4	0.00	23.4	0.000
Rural		65.9	*0.205 (0.056)*	66.6	-0.044 (.)	76.6	0.029 (0.043)
Mother attended School							
No		69.5	*0.122 (0.041)*	70.4	*0.186 (0.058)*	94.1	*0.143 (0.092)*
Yes	(Ref)	30.5	0.000	29.6	0.000	5.9	0.000
Husband attended School							
No		63.7	*0.065 (0.026)*	40.4	0.146 (0.046)	68.0	0.162 (0.044)
Yes	(Ref)	36.3	0.000	59.6	0.000	32.0	0.000
Husband in Agriculture							
No	(Ref)	50.0	0.000	42.6	0.000	75.7	0.000
Yes		50.0	-0.013 (.)	57.4	0.008 (0.029)	24.3	0.029 (0.019)
Years Before Survey							
"5-9"	(Ref)	51.4	0.000	55.2	0.000	57.8	0.000
"10-14"		48.6	0.016 (0.01)	44.8	-0.013 (.)	42.2	*0.078 (0.019)*
Region							
		Urban Governates	0.000	Khartoum	0.000	S. & East	0.000
		Urban Lower	-0.003 (.)	Eastern	0.023 (0.017)	N. & West	-0.001 (.)
		Rural Lower	*-0.068 (.)*	Central	0.006 (0.027)		
		Urban Upper	0.014 (0.01)	Darfur	0.059 (0.024)		
		Rural Upper	0 (0)	Kordofan	-0.002 (.)		
				Northern	0.015 (0.013)		
TOTAL			0.593 (0.043)		0.593 (0.052)		0.689 (0.043)

AF: Calculated from the Odds Ratios of the Survey-design Adjusted Model.
In Italics are the significant relations in the survey logistic models of Table 6.2.2A

As might be expected from the foregoing analyses, excesses in mortality risks are highest for Yemen, averaging 70 per cent, are on average 60 per cent in Sudan and Egypt, respectively. Collectively if exposures realised in the comparative model are narrowed-out, Yemen may benefit from almost a two-thirds reduction in mortality before age 5 levels, one-third of the reduction almost purely attributable to averting birth intervals of less than 18 months.

6.4 Discussion and Conclusion

This chapter is an extensive overview of a wide range of quite complex results. First to reiterate are country-specific findings robustness to the deployment of three different multivariate models, and secondly, the cross-country comparisons, collating gains resulting for each country. Sudan, Egypt and Yemen are three countries with differing achievements in lowering child mortality risks.

The multivariate analyses involved three models. The first model was a simplified approximation to those used in three of the major comparative analyses carried using data from WFS (Hobcraft, McDonald, and Rutstein 1983, 1984 and 1985). The second model allowed for the incorporation of time-varying effects of extra mortality effects in the family relative to the index child. The third model allowed adjusting for hierarchical clustering of birth within mothers and mothers' dwellings within geographical clusters (Curtis, Diamond, and McDonald, 1993; Sastry , 1997).

Regardless of model-deployment, a number of issues emerge from these analyses. The three countries could further benefit from the spacing of births, the avoidance of higher-order births, and the concentration of childbearing in the central reproductive ages. Whether the immediately previous child survives to the birth of the index child, is a clear and powerful indicator of the immediate risk for the index child in Sudan and Yemen, less so in Egypt. On the other hand, the complex effects of the interaction of birth order and older sibling mortality prior to the time of current births showed greater effects for Egypt. The time-varying risk effects due to the rare event of a new older sibling death occurring signals "instantaneous" risk for the current births in three settings. Time-varying effects associated with the status of the subsequent pregnancy offer plausible interpretable immediate risks for births in the cases of Egypt and Sudan, respectively. For Yemen, the result obtained is by no means readily interpretable.

The analysis sub-summed weakening association of child survival to socio-economic variables, more reflective perhaps of over-riding economic hardship effects.

The contextual "cluster-characteristics" variables were added to reduce unmeasured effects pertinent to the cluster-level (in the multilevel model). Overall, these variables add little explanatory power to reduce the latter effects, but some fixed-effects emerge in their own right. For Sudan and Egypt, clusters lacking planned sanitation and piped water supply are extra risk settings, while in Yemen, the disadvantage is to clusters lacking linkage to electricity supplies.

With regard to random effects, two effects are introduced, one at the cluster-level and one at the household-level. Taken over the three countries, the unmeasured effects at the cluster-level, though small in magnitude, are significant. Yet judging by the "intra-cluster" correlation coefficient, the implications compared with a marginal model that ignores the structural membership of observations within clusters would be minimal. The inclusion of random household effects via the multilevel logistic models was pertinent only to later births analysis. For Sudan, the analysis has shown a sizeable and significant household-effect unexplained by observed effects. No one interpretation readily lends itself for this effect, but this in part could be a result of the lack of "period" change seen earlier with Egypt and Yemen and the deteriorating socio-economic conditions in the country since the mid 1980s rapidly affecting households health and economics. One striking result was found in the case of Egypt, where controlling for familial history of child losses, which virtually eliminated the unmeasured effects at the household-level. Perhaps Egypt has the lowest level and hence variability in mortality, yet, knowledge about previous mortality in the household serves as a formidable indicator of the household unmeasured health-related effects. The scenario for Yemen is the most interesting one, profoundly demonstrating the "regional" dimensions of unmeasured or unmeasurable effects on child survival. The conclusion to draw about the "observed" determinants of child survival is that they are robust enough to correlations being based on models that violate independence of measurement units. The chapter finishes by generating quantitative estimates that show to what degree the prevailing levels of childhood mortality in these countries would be reduced under hypothetical changes in the distribution of maternal age at birth, birth and more opportunities of maternal schooling. The crux of change lies still with the timing of births and a realistic *health* rationale of family planning.

CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1 Introduction

This thesis is an analytical effort to extend the study of understanding changes in child mortality in the Sudan, Egypt and Yemen. Because of their geographical position, the three neighbouring countries share a great deal on the cultural and historical fronts. The three settings are also committed subscribers to the goals of the World Summit for Children in 1990 (UNICEF, 1991).

Over the past half a century these three countries enjoyed the positive gains experienced by most developing countries with improved medical technologies, better awareness about health and income growth. Yet, many hurdles remain in the path of mortality transitions for each country. Each government continues with their efforts to provide basic needs of *health for all*; clean water and sanitation to curb the spread of disease, particularly in towns and cities. Within each country vaccinations and immunisation programmes such as EPI sponsored by WHO and UNICEF are trying to maintain a high standard of immunity against childhood diseases. Maternal and Child Health programmes continue to emphasis substantial benefits of curative measures such as oral re-hydration to avert death from diarrhoea and in some settings they promote family planning use for birth spacing.

The aim of the thesis was to investigate the differentials in child mortality and how those have operated through the period between the late 1970s and the early 1990s. The main issues covered in these analyses are of interest to demographers due to the role they play in the transition to and the sustainability of lower mortality. Population priorities and dynamics at a glance seem comparable if not identical. The mortality transition started for all three in the mid 1970s. A decade later, Egypt had succeeded in slashing under-five mortality rates by almost a half, while Sudan and Yemen lagged behind. The situation in Sudan was ambiguous, the timeliness of public health interventions per se was similar to that of Egypt, yet the resultant effects were minimal. Yemen's initial mortality rates were considerably higher than the other two, and hence its declines seem less impressive.

Methods of analyses ranged from descriptive analysis with life-table methods to more complex multivariate models. Comparisons were made on country-specific basis using various models of analysis and on a "cross-country" base that allowed similarities and contrasts to be recognised.

This work was interesting in a number of ways: Firstly, rather than filling a gap, this research bridges the paradigm of the child mortality transition under-way in the three countries, especially for the Sudan and Yemen where comparative in-depth demographic investigation with regard to child mortality are scarce. Secondly, the thesis reasserts key empirical findings, whilst identifying whether relations have changed overtime. And, thirdly new evidence was unravelled about the dynamics of immediate risk spells, and unmeasured / measurable heterogeneity affecting children's survival chances in the three settings.

One main challenge lies with the complexity of creating and validating the correct sequence of the time-varying variables and the software reliability in handling large data under the realm of multi-level modelling. A review of comparative literature on child survival, as mentioned earlier, is almost absent in the case of Sudan and Yemen, and conversely abundant in the case of Egypt. Despite these challenges, useful results emerge from this work.

The following sections reiterate the conclusions reached in the course of the thesis as well as recommendations are made for policy and methodology on data requirements for further research.

7.2 Development of Activities

As with other parts of the developing world, these three settings lack reliability and completeness of vital registration system. For country-representative figures, reliance has been on sample-survey and census estimates, as far as demographic data indicators are concerned. Chapter One offers a reasonable review of country-specific demographic data, collected mainly in the second half of the last century.

By far, more demographic data is available for Egypt than it is for either Sudan and Yemen. But with the advent of the World Fertility Survey (WFS) and the Demographic and Health Surveys (DHS), the three countries had gained representative sample survey data. In Yemen, the WFS was conducted for North Yemen (formally known as the Yemen Arab Republic). Today's Yemen is a Republic formed after the 1990 unification of the Yemen Arab Republic and the People's Democratic Republic of Yemen. The WFS was conducted (1979) in Sudan, (1980) in Egypt and (1979) in Northern Yemen. Almost a decade later DHS took place in all three countries at more or less the same years; Sudan (1989/90), Egypt (1988/89) and the Unified Yemen (1991/92) catching-up with DHS-II round surveys. The DHS in Egypt and Sudan were closely followed by the Pan-Arab Project surveys for Child Health Development surveys (PAP-CHILD); a sample survey with almost an identical design to that of the DHS, for Sudan (1992/93) and Egypt (1991/92). Samples in Egypt and Yemen had national coverage while the survey for Sudan excluded the Southern States.

Limited as they may be, early demographic investigations across countries, identified a number of bio-demographic and socio-economic factors as determinants of child survival. A selective review of those, and the evolvement of methodology in analysing child mortality, is presented in Chapter Three.

On obtaining data sets, the first task was the assessment of the quality of data sections on maternity histories – reflections on that are discussed in more detail in Section 7.3 to follow. Subsequent to evidence of fair quality data, the course of the analyses took four main stages, with the general preference to rely on birth events closer to the time of survey, which proved to be more pertinent and less prone to measurement errors (e.g. recall-bias, age heaping,...etc).

The first stage was an exploratory one using life-table analysis to consolidate bivariate associations of child survival and a range of factors, bio-demographic and socio-economic. Typically, life-table methods can only offer simple tabular form without elaborate controls for potentially confounding variables.

The second stage was the individual-level analysis, which was basically a build-up process of a multivariate model, using "index" births or the observation entries of the maternity histories. A logistic regression model, that adjusts for sample design, was applied to determine the simultaneous effects of the most influential predictors on the likelihood of a child's death before age five.

Te third stage was devised to incorporate time-varying effects capturing immediate risk spells for index live births associated with child-losses in the family. Here, and after the beginning of exposure of the index births, two types of death events were "instantaneous" risks pertinent to every index birth. The death of an older sibling alive at the time of birth of the index child and death of a subsequent birth, younger than the index child within the 60 months exposure of early childhood years. Resorting to Cox model, to incorporate time-varying effects, also ameliorated the need to exclude recent births from the analysis because of censoring.

In the fourth stage multilevel modelling was performed to achieve a two-fold objective, to make allowance for the correlation between observations in the logistic multivariate relation and, to quantify unmeasured heterogeneous effects at levels of structural clustering, i.e. the household level as a level of clustering of births; and the sample cluster as a higher level of clustering of households. Further still, from the household survey the analysis used information on amenities of households where mothers dwelt to quantify proxy contextual measures at the cluster level.

As with many studies handling maternity histories, this study was denied inclusion of any extra information on child health dimensions collected by maternal and child health section for more recent births. In Chapters Four and Five detailed results were presented as obtained from the model-based analyses described above.

7.3 Methodological Lessons and Issues of Data Quality

As more detailed information became available with revised and improved demographic sample surveys, advanced methodology in data analysis continued to develop. Yet methodology, as sophisticated as it may get, has little to offer in remedying poor quality data.

With the inclusion of live-birth histories in demographic sample surveys, certain procedures were almost *templated* to check for data quality issues (Curtis, 1995; Marckwardt and Rutstein, 1996). Chapter Two of this thesis offers results from a number of data checks done on the live-births histories prior to executing analytical work. Egypt emerges with the best data in consistency and level of completeness. For Sudan and Yemen, a few problems were detected, relating to date reporting (of children ages and ages at death), and what is assumed to be involuntary omission of dead children (females more than males). The propensity for digit preference in reporting, for instance, age at death as 12 months, was recurrent comparing PAP-CHILD to earlier surveys. Overall the dependent variable used by this study, mortality under-5, was least affected by that tendency.

The results of the data quality assessment suggest a few recommendations such as introducing more check boxes (in future PAP-CHILD surveys) to aid interviewers with data checks on missing information and digit preference reporting. Given that substantial shifting of births was observed in the cases of Sudan and Yemen (to reduce work load with regard to collecting more health information on recent births) more training and better quality interviewers are necessary to reduce the incidence of such events.

The three surveys adopted a "*de jure*" approach in the selection process of respondents' eligibility for the reproductive health detailed interview. Rutstein and Bicego (1990) showed that there are gains to be made in the reporting of the "*de facto*" status (i.e., in reducing "sleeping away" exclusion). This study showed evidence of minor shifting of women, particularly outside the upper bound of the age eligibility criteria. Future PAP-CHILD surveys should perhaps consider a "*de facto*" sample of ever-married women age 15-54 which would far outweigh the effects of increasing displacement at the border of eligibility.

Although the assessment found that the overall quality of the data was good, the analyses proceeded with mortality before age five as the dependent variable. The emphasis should be placed, however, on minimizing non-sampling errors through modifications in future PAP-CHILD survey questionnaires, improved interviewer training, improved instruction manuals, and follow-up visits to a sample of respondents by field editors

On the methodology front, the availability of statistical tools to manage multilevel models for binary dependent variables perhaps have still more room to grow given the complexity of the estimation process which entails complex approximation (e.g. the new ideas behind MCMC estimation). Noted in this analysis is the sensitivity of the convergence criterion used by quasi-likelihood methods in MLwiN to the sparsity of observations units at level 1 (the births level) and the rarity of the event of interest (i.e. the dependent variable, death of a child). Rodríguez and Goldman (1995) encountered substantial biases in the estimates of the fixed effect and/or the variance components whenever the random effects are sufficiently large or, the number of observations within a given level of clustering (e.g. the family) is too small[1] .

The assumption of lack of correlation between unmeasured effects and observed effects might not be all that valid. In the case of Yemen, the multi-level model with only bio-demographic correlates, reduces the household unmeasured effects close to zero, but as socio-economic correlates are added to the model the magnitude and significance of the unmeasured effect variance component recovers to a value significantly away from zero.

Trussell and Rodriguez (1990) reviewed a number of studies on unobservable heterogeneity in the context of hazard regressions used for event history analysis. They concluded that the methods proposed to correct for unobservable heterogeneity deliver less than is commonly assumed, particularly because of an inherent non-identifiability involved when the analyst must rely on observables to assess goodness-of-fit. On the other hand the models will usually have radically different behavioural implications, posing serious problems for theory building, particularly in most demographic applications where previous knowledge does not provide firm guidance regarding the shape of the latent hazard (Trussell and Rodriguez, 1989).

With smaller families (as in the case of Egypt), fewer numbers are available at level 1 to suit multi-level models. Goldstein (1995) argues that so long as there is a larger number at level 2, estimates will be reliable. Resorting to using an unequal correlation structure (for example, stationary or non-stationary) might have offered a solution; that proved not to be straight forward, since the estimating procedure requires starting values of the correlation structure, which are at not simple to pre-determine.

[1] They suggest the use of Gaussian quadrature for relatively simple binary response models, such as the 2 and 3 levels variance component models.

From the analytical perspective, as the amount of precision with which one wants to examine the child survival process increases, so does the demand for ever larger samples. Measurements at the district / community levels are desperately needed since, as indicated in Chapter One, the district or equivalent is the appropriate location in most health systems to consolidate PHC strategy, and where management decisions can be made with close relevance to local conditions.

7.4 Principal Findings

Fundamentally, the thesis has reiterated that key risk effects still lie with young ages of child-bearing and with short birth intervals; these are persistent in the face of all controls that have so far been attempted, including those for socio-economic status, survival for the preceding child, sex, familial mortality measures and random effects due to unmeasured or unmeasurable factors. (Hobcraft, McDonald, and Rutstein 1983, 1985; Palloni and Millman, 1986; Guo, 1993; Curtis, Diamond, and McDonald, 1993; Hobcraft, 1994; and, Curtis and Steele, 1996).

To remind the reader, in the three settings, marriage is universal, and more than three quarters of the populations are Muslims to whom marriage is essential prerequisite for fertility. These are traditional societies in which female ages at marriage remained low, and only during the past decade did regional parts began to experience a rise in ages at marriage – partly caused by increased schooling and female employment chances particularly in Egypt and Sudan.

7.4.1 Bio-demographic Differentials In Child Survival

First to consider is the gender-bias in child survival. Male births exhibit higher risks of death (more so in infancy) in both Sudan and Yemen but not in Egypt. Behind that finding, is *unintentional* underreporting of female deaths in the cases of Sudan and Yemen, clearly demonstrated by data quality checks and the multivariate analysis. Egypt was identified as the country with strongest son preference among 25 countries covered by the DHS (Arnold, 1992); this could suggest female births suffer salient disadvantaged conditions with more care and resources allocated to male births (Makinson, 1986; Ahmed, 1990) which could not be investigated by this study.

Births to very young women elevate the risks to mother and child. In these settings, childbearing starts relatively early, before age 18 years, and the risk of death are typically higher for first births compared to later births. Yet one expects as parity rises thereafter, the risk of maternal mortality also climbs. In other words, the underlying risks directly attributable to the age of the mother are often exacerbated by other forms of social, economic and environmental deprivation being themselves associated with an early start to child-bearing (Hobcraft, 1987).

Patently, and cross-countries, there is no larger effect than that of birth spacing. Close to a quarter of births in Egypt and Sudan result from a birth interval of less than 18 months and in Yemen the figure is almost double that. Compared to prolonged birth interval of 24-35 months, the risk is of death is almost three-fold for children born after a short preceding birth interval (less than 18 months) in Egypt and Yemen; for Sudan the same risk is slightly less. The analyses illustrate a radical reduction in child mortality as a result of prolonged birth intervals, reducing by half the risk of death before age five.

The salience of previous mortality measures as determinants of mortality cannot be stressed enough. Controlling for the survival status of the immediately previous birth is imperative to understanding immediate health risks, especially during infancy, pertinent to the index child. Easier to demonstrate is the trend of excess risk association to mortality before age five in the cases of Sudan and Yemen than Egypt. Consistently, children born after short intervals experience excess mortality, regardless of the previous child survival status. This finding demonstrates that competition with surviving children cannot be the dominant source of observed association. On the contrary, such results point towards maternal depletion or an underlying common cause (Cleland and Sathar, 1984; Hobcraft, 1987). Especially in the case of Yemen, and to a lesser extent Sudan, so long as fertility is high, and in conditions of moderate mortality levels, the argument supports a scenario of more maternal depletion than siblings' competition.

Deaths may also be clustered over time in certain households. To investigate survival correlations, complex interaction terms were introduced relating children's birth orders to counts of older siblings deaths. Perhaps these terms have first precedence here and closest in comparison to the work by Hobcraft (1994). Despite the fact that indicators had comparable frequency distribution in the three samples, inferences drawn varied for each. In the case of Egypt, there was strong evidence to show additive risks as the counts of deaths increased with increasing parity groups. In the cases of Sudan and Yemen the additive risk was subtly confined to higher parities. Harder to explain is the beneficial "state" higher parities seem to show when there have been no older sibling deaths in the cases of Sudan and Yemen. If one accepts the differential as an indicator of health conditions in the household, in Sudan and Yemen the household health conditions might not have varied in the period concerned, hence the subtle indications of extra risk. Whilst the opposite argument could easily apply in the case of Egypt, where estimates of excess risk remain sizeable.

On monitoring an index child for extra events of mortality in the household during the first 60 months of exposure, one can observe two types of events; that of an older sibling dying or a subsequent birth conceived, born and then dying shortly after. The event of death of an older sibling(s) was a rare event in all sub-samples yet the result reinforces the suggestion made earlier. Instantaneously, the risk of death before age five maybe trebled for the index child. Less obvious is the effect associated with the status of the subsequent births. The ambiguity arises from the concept of reverse causality. Here and with such a transient effect, the choice is to focus on the immediately subsequent birth. Hobcraft (1987) recommended incorporating time-varying effects of the subsequent birth status (dependent also on the index child survival time) to avoid reverse causality effects. That has been captured by a time-varying variable acquiring one of four states, no conception, a conception, a subsequent birth and a subsequent death, respectively. Considering the first five years of their lives, half of births cohorts were followed by a subsequent birth. When a subsequent conception takes place the "instantaneous" risk of death before age five is at least doubled in the cases of Sudan and Egypt but remains moderate in the case of Yemen. The same scenario repeats when there has been a subsequent birth. But in the case of a subsequent death, the risk level climbs close to three-fold for births in Egypt and Sudan. In the case of Yemen, estimates show an inexplicable reversed effect which makes unequivocal distinction difficult.

7.4.2 Socio-economic Differentials In Child Survival

Results of the multivariate analyses suggested intriguing differences in the relative roles of different socio-economic variables. With the exception of Rural Egypt, differential effects in survival chances attributable to urban-rural residence remain subdued. This is probably a by-factor of controlling for over-riding socio-economic effects of parental education and husbands occupation.

All three-settings demonstrate a promising picture with respondents' education which exerts a positive influence in reducing child mortality. Egyptian mothers' with schooling seem to be more of an influence on their children survival chances – a finding confirmed for Egypt elsewhere by Bicego and Boerma (1993) examination of 17 DHS surveys. Similarly for Sudan the advantage is observed but the whole effect almost disappears when husbands schooling status is controlled for. Even in Yemen, a country of low levels of female literacy, more maternal schooling points towards better survival rates for their children. This is impressive to see since the association could weaken with the catalytic effect of economic hardships experienced by Sudan and Yemen during the 15 years covered by this analysis.

Considering births to mothers whose husbands had no schooling, the prevalence is highest in Yemen, followed by Sudan and lowest in Egypt, respectively. The disadvantage with the lack of husbands schooling is a common finding, perhaps greater in Sudan followed by Yemen and lastly Egypt. There are grounds for doubting the validity of the categorisation of occupation, which shows pronounced risks of early childhood mortality only in the case of Yemen.

One striking finding is how the analysis captures "period" effects of changes of mortality for all three countries. The effects are attributable more to macro / exogenous in nature following from improved living conditions, public health interventions across the board from family planning, immunisation, MCH and so forth. Hence a downward trend is expected when comparing earlier and more recent periods. For Egypt and Yemen, the results were reassuring, with recent years (i.e. the late 1980s) showing close to halving of risk hazards compared to the late 1970s. But for Sudan, though insignificant, the time trend suggests a resurgence of higher mortality rates in the five-years period prior to the survey. The estimates for Sudan consistently reveal a stagnant situation, with period-effects hardly making a difference in the 15 years before the survey date (roughly the period of late 1970s – early 1990s).

7.4.3 Unmeasured Effects and Child Survival

One special interest is the implication of the unmeasured/ unmeasurable factors in inducing clustering of mortality effects. Analysis with multi-level models incorporated extra effects unmeasurable at the hierarchical levels of clustering of these births inherited vis-à-vis the sampling design. Within the constraints of country level definitions and units of levels, two levels of hierarchical clustering were adjusted for: clustering of children to the same mother, and clustering of mothers / household within geographical clusters. The more substantial of the two was the unmeasured effects quantified at the household level.

On the whole, clusters of residence were more homogenous in mortality risks due to unmeasured effects hence yielding weak "intra-cluster" correlation coefficients. To make more use of measurables, an attempt was made to gain extra explanatory power with cluster-characteristic variables to reduce unmeasured effects at the cluster level.

The analyses give a clear message for more investment in securing clean water supply, proper sanitation, which are obvious promoters of child survival. The presence of utilities, such as electricity supplies, indicate and facilitate community services related to health and the environment.

In considering the random variance components at the two hierarchical levels a number of findings emerge. The worrisome of the two, the household unmeasured effect, was eliminated after controlling for the familial measures of child losses in the final multivariate relation chosen for Egypt. In the case of Yemen, results were most striking, clearly indicating that unmeasured heterogeneity, whether at the cluster or the household level, had a "regional" effect on children's survival chances. In the case of Sudan, results were more frustrating where random effects of unmeasured / unmeasurable factors at the household level were irreducible even when the whole array of fixed effects were added. Yet the cluster-effect "responds" and reduces in size and significance when socio-economic factors and cluster characteristics are adjusted for.

On the whole, the experience of adjusting for unmeasured effects induced minimum shifts in fixed effects described above, with key significant associations remaining robust to any attenuation. One exception is the effect associated with the survival status of the immediately previous birth in Sudan, which seems to drop in size and significance in the multi-level model.

In conclusion, gains from varying models of analysis have been insightful. With the multi-level framework the analysis extended findings to encompass a "regional" dimension for the unmeasured effects, flagging serious policy concerns. In the case of Egypt, the two regions, Urban Governates (Cairo & Alexandria) and Upper Rural Egypt showed similar levels of unmeasured heterogeneity in levels of child mortality, yet causes and consequences are by far dissimilar. In the case of Sudan, Darfur in the west, remains as the region of with highest health concerns with regard to child survival – yet even when homogeneity in mortality risks is showing for the other regions, that would not imply better survival conditions. This can be well-demonstrated by the case of Yemen, where the "South & East" region shows considerable heterogeneity in child survival at the clusters level, where the health and social care provisions are operating. That could pose the question about the accessibility, quality and equality of the distribution of services. Yet, the "North & West" region shows lower heterogeneity at the cluster-level and more at the immediate family or parental level. In other words, in the presence or otherwise of health and social care, exactly how enabled and equally capable are these families and household in bettering the chances of their children survival.

Relatedly, there is far more to be discovered about synergisms, or risk enhancing factors: interactions of poverty, familial environment, education, health care practices and access to health care with the biological risk factors. Better suited for such investigations are perhaps longitudinal rather than cross-sectional studies, aided perhaps with an intensive qualitative data tool.

7.5 Policy Implications

Using sample-surveys for the past three decades has served well in delivering key findings to shape country-specific and international child health policies. For developing countries similar to the three examined in this analysis, sample surveys remain one manageable and reliable tool of data collection, especially in the absence of complete and reliable vital registration data. What this analysis observes is that the seemingly comparable localities may still remain each with its own list of priorities in population policy.

One can perhaps divide measures for ensuring better child survival into preventive and curative ones. The thesis was able to at address the first one – child losses could be prevented profoundly by increasing spacing between births. It has been customary to regard declines in infant and child mortality as a critical stimulant of the adoption of family limitation, but the opposite holds as well; effective fertility control can contribute significantly to the reduction in child losses. In a country of high fertility like Yemen, the uptake of fertility regulation would bring about positive effects on survival chances of children. Child bearing starts too early for Yemeni women (median age at marriage is 15.8 years) and early pregnancies among high-risk groups (women under age 20) are quite prevalent. For these young mothers, the uptake of any sort of contraception before first births is almost implausible and delaying entry to marriage could be the only solution to avoid high-risk pregnancies and pregnancy wastage. For middle age-groups (20-35 years) there is a lot to be determined-mothers need to build-up their confidence in the survival chances of their young ones, before they would decide on regulating or terminating their child bearing cycle. One of the long-term goals of public information campaigns is to instil among mothers realistic perceptions of risk.

The new wheels of change are perhaps through the concepts of social diffusion: an example is the study by Rosero Bixby and Casterline (1995) using a focus group discussion with Costa Rican women in their 50s in 1993 (from the cohorts that live through the fertility transition). To these women, high child morality was not perceived as a reason for having large families in the past, nor was its reduction seen as a reason for the shift to the small family of today. Their study however identifies two possible links to low child mortality hypothesis as in: namely, i) that family planning messages are often diffused in waiting rooms of health centres where increasing numbers of mothers were taking their children for preventive curative care and, ii) the burden of helping their mothers to rear a large family was a motivation for wanting a small family.

From a curative perspective, a mother or a family with a history of any child loss, even in the distant past, is a family at risk of losing a few more in the future to come; those should be targeted and monitored. As a definite target group, more efforts should be made to discover these settings, by out-reach MCH/FP programmes, rather than just relying on large increases in intervention. Becker and Black (1996) originated models combining epidemiological and demographic parameters to predict the effects of various mixes and levels of interventions, which has shown, for a South Asian setting, large increases in intervention coverage do not necessarily lead to large decreases in mortality. They argue the need to implement a complementary set of preventive (e.g. clean water and good sanitation) and therapeutic interventions (e.g. breastfeeding during the first six months of life and oral rehydration therapy) addressing the common causes of mortality in children – diarrhoea, measles, tetanus, malaria and pneumonia. They suggest such a package of interventions, with potentially achievable coverage levels, could reduce child mortality by up to 40 per cent, a result consistent with the UNICEF Summit targets.

But many gaps notoriously exist between knowledge and practice. Taking the example of using ORS to cure diarrhoea, in Sudan and Egypt knowledge about ORS was almost universal – but amongst children who experienced a diarrhoeal episode in the past 2 weeks before the PAP-CHILD surveys only one fifth of mothers have actually used ORS in the two countries.

It is widely believed that education is part of a global process of social change towards "modernisation". The Sudan is a country that has been expending billions of hard currency on its civil war, the industry is stagnant with very little reliance on agricultural exports. The country withdraws its support from key channels of health and education. Will maternal education still make a difference to child survival – the immediate answer in not certain. The blanketed effect of economic hardship overshadows gains usually attributable to maternal education. Even for a country like Egypt, where there has been a remarkable fertility transition, the pressures on the Egyptian society generated by continuing population growth endanger the success of policies designed to improve child survival. Myntti (1993) observed, in the case of Yemen, that what distinguished women with healthy and unhealthy children was the level of resources under their control and the way they managed them; their social support or lack of it; and their passive or active attitudes toward life.

Last but not least, governments might need to pay attention to the more complex nutritional floor argument relating to food price and subsidies: letting people buy basic foodstuffs more cheaply can, in theory , increase intake of particular foods, but there are often practical problems in targeting subsidies to needy households.

7.6 Further Work in Child Survival

The unique and crucial contribution that can be made by sample-surveys depends on repetition of surveys that use comparable sampling frames and methods of measurements. Since 1993, Sudan has not been re-visited with any demographic and health sample survey, and the situation is unlikely to improve.

Future, interest remains with repeated surveys being conducted in Egypt and Yemen to monitor the change in differentials of under-five mortality.

More recently, the full Bayesian treatment has become computationally feasible with the development of Markov Chains Monte Carlo (MCMC) methods, especially Gibbs Sampler (Zeger and Karim, 1991) and Metropolis-Hastings (Gilks and

Roberts, 1996). This has the advantage, in small samples, that it can take account of uncertainty associated with the estimate of the random parameters and can provide exact estimates of uncertainty (Goldstein, 1995). Also the problem of correct identification of the distribution of unmeasured effects could be a signal for more complex methods of MCMC to be used.

One key finding was that adjusting for the record of previous child losses in the family "explains" households' unmeasured effects. Would that finding prevail in other settings if fair quality birth history data were available, especially in settings with considerable levels of child mortality. It could be the case that once the households effects are fully explained by child fatalities within them, then the ceiling of differential unmeasured effects is diminished – that is whatever else remains are products of the environment the household unit dwells in. In other words, effects are cumulative on "familial-mortality".

Methodologically, interests remains in implementing time-varying features of siblings' mortality in an attempt to disentangle more of the unmeasurable effects as in the case of Sudan. This has recently become more available with the handling of Cox models in multi-level modelling packages. Also could there be possible time-varying dependence of child survival on unobservable family-traits (for example, on the realm of structural equations modelling with hierarchical data)– and there would be room for varying the distributions assumed for unmeasured effects.

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Appendix

The following tables present five columns showing the progression in regression models from the survey-design adjusting logistic model, the converted Odds Ratios to Relative Risks (OR*) as calculated by the formula on page 123, the Cox regression model excluding and including time-varying effects and lastly the multi-level logistic model results. Tables include the calculated approximation of the survey-design adjusted logistic model to provide the reader the chance to observe the comparability of odds ratios to relative risks obtained by the Cox model.

Table A1 Egypt (1991): Comparative Results for Survival to age 5 of First-Births

Correlates		N=3326	Survey Logistic		Cox Model		Multi-level Logistic
		(%)	OR (95 % C.I.)	OR* (95 % C.I.)	RR (95 % C.I.)	RR (95 % C.I.)	MLOR (95 % C.I.)
Sex							
Male		52.7	1.14 (0.93,1.41)	1.12 (0.94,1.35)	1.12 (0.94,1.32)	1.13 (0.95,1.34)	1.16 (0.93,1.43)
Female	(Ref)	47.3	1.00	1.00	1.00	1.00	1.00
Mother's age at birth							
< 18 years		22.0	1.51*** (1.15,1.97)	1.43*** 1.13,1.77)	1.51*** (1.22,1.88)	1.53*** (1.23,1.90)	1.43*** (1.09,1.87)
18-19 years		20.5	0.88 (0.65,1.2)	0.89 (0.68,1.17)	0.94 (0.73,1.19)	0.95 (0.75,1.22)	0.88 (0.65,1.19)
20-24	(Ref)	37.6	1.00	1.00	1.00	1.00	1.00
25-29		15.7	0.59*** (0.40,0.88)	0.62*** (0.43,0.89)	0.72** (0.52,0.99)	0.73* (0.53,1.00)	0.6** (0.4,0.9)
30-34		3.2	1.19 (0.65,2.18)	1.16 (0.68,1.92)	1.04 (0.61,1.78)	1.04 (0.61,1.77)	1.21 (0.63,2.32)
35 +		1.0	1.13 (0.33,3.84)	1.11 (0.36,2.9)	1.95* (0.93,4.10)	2.03* (0.96,4.28)	1.10 (0.31,3.89)
Area of Residence							
Urban	(Ref)	39.5	1.00	1.00	1.00	1.00	1.00
Rural		60.5	1.57*** (1.18,2.1)	1.50*** (1.16,1.94)	1.55*** (1.22,1.97)	1.54*** (1.21,1.95)	1.37** (1.01,1.85)
Mother attended School							
No		54.7	1.44** (1.08,1.91)	1.39** (1.07,1.78)	1.26** (1.00,1.58)	1.24* (0.99,1.56)	1.37** (1.04,1.82)
Yes	(Ref)	45.3	1.00	1.00	1.00	1.00	1.00
Husband attended School							
No		28.0	1.13 (0.88,1.45)	1.12 (0.89,1.39)	1.17 (0.95,1.43)	1.17 (0.95,1.44)	1.14 (0.89,1.46)
Yes	(Ref)	72.0	1.00	1.00	1.00	1.00	1.00
Husband in Agriculture							
No		36.0	1.00	1.00	1.00	1.00	1.00
Yes	(Ref)	64.0	1.07 (0.82,1.39)	1.06 (0.84,1.33)	1.09 (0.89,1.34)	1.10 (0.90,1.35)	1.02 (0.79,1.33)
Years Before Survey							
"0-4"					0.61*** (0.48,0.77)	0.63*** (0.50,0.80)	
"5-9"	(Ref)	50.6	1.00	1.00	1.00	1.00	1.00
"10-14"		49.4	1.17 (0.95,1.44)	1.15 (0.96,1.37)	1.14 (0.94,1.38)	1.14 (0.95,1.38)	1.19 (0.96,1.48)

...................*(Continues next page)*

Table A1 Egypt (1991): Comparative Results for Survival to age 5 of First-Births ……………………………….*(Continued)*

Correlates	N=3326 (%)	Survey Logistic OR (95 % C.I.)	Survey Logistic OR* (95 % C.I.)	Cox Model RR (95 % C.I.)	Cox Model RR (95 % C.I.)	Multi-level Logistic MLOR (95 % C.I.)
Status Subsequent Birth						
0 = None (Ref)	49.6				1.00	
1 = Conception	26.1				2.52*** (1.92,3.32)	
2 = Birth	22.0				1.85** (1.06,3.23)	
3 = Death	2.3				2.60* (0.98,6.85)	
Clusters' Utility						
Electricity (Ref)	96.8					1.00
None	3.2					0.87 (0.48,1.6)
Clusters' Sanitation						
Toilet/Shared (Ref)	75.2					1.00
Pit/Latrine	15.1					1.71*** (1.29,2.25)
Open-Air/Other	9.7					1.12 (0.78,1.61)
Clusters' Water Supply						
Gover-Piped (Ref)	80.7					1.00
Well/Pumped	19.3					1.25 (0.96,1.64)
Other	100.0					

***=sig. (0.001) , **=sig. (0.05), *=sig. (0.1)
OR* = are the transformed svy-logistic Odds Ratios using formulae on page 123.

Table A2 Egypt (1991): Comparative Results for Survival to age 5 of Higher-Order Births

Correlates	N=13263 (%)	Survey Logistic OR (95 % C.I.)	Survey Logistic OR* (95 % C.I.)	Cox Model RR (95 % C.I.)	Cox Model RR (95 % C.I.)	Multi-level Logistic MLOR (95 % C.I.)
Sex						
Male	51.2	0.94 (0.84,1.06)	0.95 (0.86,1.05)	0.96 (0.89,1.04)	0.98 (0.90,1.06)	0.95 (0.85,1.05)
Female (Ref)	48.8	1.00	1.00	1.00	1.00	1.00
Mother's Age at Birth						
< 18 years	2.7	1.44*** (1.09,1.90)	1.35*** (1.07,1.66)	1.35*** (1.09,1.67)	1.33*** (1.07,1.65)	1.43** (1.08,1.89)
18-19 years	5.1	1.03 (0.81,1.32)	1.03 (0.84,1.26)	1.04 (0.87,1.25)	1.04 (0.87,1.25)	1.04 (0.83,1.32)
20-24 (Ref)	27.0	1.00	1.00	1.00	1.00	1.00
25-29	29.7	0.89 (0.77,1.03)	0.91 (0.80,1.03)	0.88** (0.78,0.98)	0.88** (0.79,0.99)	0.89 (0.77,1.03)
30-34	21.4	0.81** (0.68,0.98)	0.84** (0.72,0.98)	0.84** (0.74,0.96)	0.86** (0.75,0.99)	0.80** (0.67,0.96)
35 +	14.0	0.91 (0.75,1.11)	0.92 (0.78,1.09)	0.97 (0.82,1.13)	1.02 (0.87,1.20)	0.90 (0.72,1.12)
Previous Birth Interval						
< 18 month	24.0	2.80*** (2.44,3.22)	2.33*** (2.10,2.57)	2.48*** (2.23,2.76)	2.35*** (2.11,2.61)	2.81*** (2.45,3.22)
18-23 month	17.4	1.50*** (1.28,1.75)	1.42*** (1.24,1.61)	1.48*** (1.31,1.68)	1.45*** (1.28,1.64)	1.49*** (1.27,1.74)
24-35 month (Ref)	28.7	1.00	1.00	1.00	1.00	1.00
36+ month	29.8	0.57*** (0.48,0.66)	0.60*** (0.51,0.69)	0.65*** (0.57,0.74)	0.65*** (0.57,0.74)	0.56*** (0.47,0.67)
Previous Child Survived to Birth of Index Child						
Yes (Ref)	85.9	1.00	1.00	1.00	1.00	1.00
No	14.1	1.50*** (1.31,1.71)	1.41*** (1.26,1.57)	1.51*** (1.37,1.67)	1.50*** (1.36,1.65)	1.39*** (1.21,1.58)
Birth Order X Previous Deaths						
B2-3 X 0 death (Ref)	39.8	1.00	1.00	1.00	1.00	1.00
B4-6 X 0 death	20.9	1.07 (0.91,1.26)	1.06 (0.92,1.22)	1.04 (0.91,1.18)	1.04 (0.91,1.19)	1.07 (0.90,1.27)
B7+ X 0 deaths	3.3	1.54*** (1.11,2.14)	1.45*** (1.10,1.88)	1.29** (1.00,1.66)	1.27* (0.99,1.63)	1.57*** (1.13,2.17)
B2-3 X 1 deaths	3.4	1.81*** (1.40,2.35)	1.65*** (1.34,2.02)	1.71*** (1.40,2.07)	1.67*** (1.37,2.03)	1.82*** (1.41,2.36)
B4-6 X 1+ deaths	12.0	1.79*** (1.50,2.15)	1.64*** (1.42,1.89)	1.61*** (1.41,1.84)	1.59*** (1.39,1.82)	1.76*** (1.48,2.10)
B7+ X 1+ deaths	4.6	1.55*** (1.18,2.04)	1.45*** (1.16,1.81)	1.5*** (1.22,1.84)	1.46*** (1.19,1.8)	1.56*** (1.17,2.06)
B4-6 X 2+ deaths	5.4	2.11*** (1.67,2.65)	1.86*** (1.55,2.21)	1.79*** (1.51,2.13)	1.76*** (1.48,2.09)	1.96*** (1.56,2.46)
B7+ X 2+ deaths	10.6	1.96*** (1.6,2.39)	1.76*** (1.49,2.05)	1.84*** (1.57,2.16)	1.81*** (1.55,2.13)	1.87*** (1.51,2.32)
Area of Residence						
Urban (Ref)	34.2	1.00	1.00	1.00	1.00	1.00
Rural	65.9	1.26*** (1.08,1.47)	1.23*** (1.07,1.4)	1.23*** (1.10,1.37)	1.20*** (1.08,1.33)	1.22** (1.03,1.43)

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Table A2 Egypt (1991): Comparative Results for Survival to age 5 of Higher-Order Birth ....Continued

Correlates	N=13263 (%)	Survey Logistic OR (95 % C.I.)	Survey Logistic OR* (95 % C.I.)	Cox Model RR (95 % C.I.)	Cox Model RR (95 % C.I.)	Multi-level Logistic MLOR (95 % C.I.)
Mother attended School						
No	69.5	1.26*** (1.09,1.47)	1.23*** (1.08,1.40)	1.21*** (1.08,1.36)	1.19*** (1.06,1.33)	1.24*** (1.08,1.44)
Yes (Ref)	30.5	1.00	1.00	1.00	1.00	1.00
Husband attended School						
No	63.7	1.17*** (1.04,1.32)	1.15*** (1.03,1.27)	1.17*** (1.07,1.29)	1.17*** (1.06,1.28)	1.18*** (1.04,1.34)
Yes (Ref)	36.3	1.00	1.00	1.00	1.00	1.00
Husband in Agriculture						
No	50.0	1.00	1.00	1.00	1.00	1.00
Yes (Ref)	50.0	0.96 (0.85,1.09)	0.97 (0.87,1.08)	1.00 (0.91,1.10)	1.00 (0.91,1.10)	0.97 (0.86,1.11)
Years Before Survey						
0-4				0.68*** (0.61,0.76)	0.70*** (0.62,0.78)	
5-9 (Ref)	51.4	1.00	1.00	1.00	1.00	1.00
10-14	48.6	1.09* (0.98,1.22)	1.08* (0.98,1.18)	1.08* (0.99,1.18)	1.05 (0.96,1.15)	1.10* (0.99,1.23)
Extra Sibling Deaths						
None (Ref)	97.9				1.00	
1 Extra deaths	2.1				3.43*** (2.72,4.33)	
Status Subsequent Birth						
0 = None (Ref)	60.5				1.00	
1 = Conception	19.8				2.35*** (2.04,2.7)	
2 = Birth	18.0				2.46*** (1.93,3.15)	
3 = Death	1.8				2.62*** (1.71,4.01)	
Clusters' Utility						
Electricity (Ref)	96.6					1.00
None	3.4					0.97 (0.66,1.43)
Clusters' Sanitation						
Toilet/Shared (Ref)	71.6					1.00
Pit/Latrine	17.2					1.29*** (1.09,1.53)
Open-Air/Other	11.3					1.08 (0.88,1.33)
Clusters' Water Supply						
Gover-Piped (Ref)	79.0					1.00
Well/Pumped	21.0					1.03 (0.87,1.21)
	100.0					

***=sig.(0.001), **=sig.(0.05), *=sig. (0.1) OR* = Transformed svy-logistic Odds Ratios using formulae on page 123.

Table A3 Sudan (1992/93): Comparative Results for Survival to age 5 of First-Births

Correlates		N=1646 (%)	Survey Logistic OR (95 % C.I.)	OR* (95 % C.I.)	Cox Model RR (95 % C.I.)	RR (95 % C.I.)	Multi-level Logistic MLOR (95 % C.I.)
Sex							
Male		52.9	1.38^{**} (1.00,1.90)	1.33^{**} (1.00,1.73)	1.16 (0.92,1.45)	1.16 (0.92,1.45)	1.38^{**} (1.02,1.88)
Female	(Ref)	47.1	1.00	1.00	1.00	1.00	1.00
Mother's age at birth							
< 18 years		33.2	1.28 (0.89,1.83)	1.24 (0.90,1.67)	1.26 (0.95,1.67)	1.26 (0.95,1.68)	1.28 (0.88,1.85)
18-19 years		19.8	1.16 (0.74,1.81)	1.14 (0.76,1.65)	1.15 (0.84,1.58)	1.17 (0.85,1.6)	1.13 (0.74,1.74)
20-24	(Ref)	32.2	1.00	1.00	1.00	1.00	1.00
25-29		11.2	0.78 (0.42,1.47)	0.80 (0.45,1.39)	0.82 (0.54,1.25)	0.82 (0.53,1.25)	0.77 (0.43,1.38)
30-34		3.0	0.52 (0.16,1.73)	0.55 (0.18,1.59)	0.62 (0.28,1.41)	0.64 (0.28,1.45)	0.52 (0.15,1.77)
35 +		0.6	0.87 (0.09,8.22)	0.88 (0.10,4.49)	1.32 (0.42,4.17)	1.40 (0.45,4.39)	0.82 (0.10,6.88)
Area of Residence							
Urban	(Ref)	36.5	1.00	1.00	1.00	1.00	1.00
Rural		63.5	1.24 (0.85,1.81)	1.21 (0.86,1.67)	1.15 (0.86,1.53)	1.15 (0.87,1.54)	1.21 (0.80,1.83)
Mother attended School							
No		51.3	0.97 (0.65,1.44)	0.97 (0.68,1.38)	1.27 (0.94,1.71)	1.26 (0.94,1.70)	0.94 (0.63,1.39)
Yes	(Ref)	48.7	1.00	1.00	1.00	1.00	1.00
Husband attended School							
No		41.3	2.09^{***} (1.40,3.11)	1.89^{***} (1.35,2.59)	1.52^{***} (1.15,2.03)	1.51^{***} (1.14,2.01)	2.06^{***} (1.40,3.03)
Yes	(Ref)	58.7	1.00	1.00	1.00	1.00	1.00
Husband in Agriculture							
No		67.4	1.00	1.00	1.00	1.00	1.00
Yes	(Ref)	32.6	0.70^{*} (0.48,1.02)	0.73^{*} (0.51,1.02)	0.84 (0.64,1.12)	0.84 (0.63,1.11)	0.67^{**} (0.46,0.98)
Years Before Survey							
"0-4"					1.10 (0.83,1.46)	1.14 (0.86,1.52)	
"5-9"	(Ref)	53.3	1.00	1.00	1.00	1.00	1.00
"10-14"		46.7	0.81 (0.6,1.11)	0.83 (0.63,1.09)	0.83 (0.63,1.09)	0.84 (0.64,1.11)	0.82 (0.61,1.12)

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Table A3 Sudan (1992/93): Comparative Results for Survival to age 5 of First-Births.................................*(Continues)*

Correlates	N=1646 (%)	Survey Logistic OR (95 % C.I.)	Survey Logistic OR* (95 % C.I.)	Cox Model RR (95 % C.I.)	Cox Model RR (95 % C.I.)	Multi-level Logistic MLOR (95 % C.I.)
Status Subsequent Birth						
0 = None (Ref)	49.5				1.00	
1 = Conception	25.2				1.77*** (1.17,2.69)	
2 = Birth	23.7				1.19 (0.58,2.45)	
3 = Death	1.6				3.99*** (1.61,9.90)	
Clusters' Utility						
Electricity (Ref)	32.2					1.00
None	67.8					1.36 (0.84,2.22)
Clusters' Sanitation						
Toilet/Shared (Ref)	4.5					1.00
Pit/Latrine	62.2					0.47* (0.20,1.10)
Open-Air/Other	33.3					0.48** (0.23,1.00)
Clusters' Water Supply						
Gover-Piped (Ref)	32.7					1.00
Well/Pumped	19.7					0.85 (0.48,1.50)
Other	47.6					1.18 (0.73,1.91)
	100.0					

***=sig. (0.001) , **=sig. (0.05), *=sig. (0.1)
OR* = are the transformed svy-logistic Odds Ratios using formulae on page 123.

Table A4 Sudan (1992/93): Comparative Results for Survival to age 5 of Higher-Order Births

Correlates	N=8498 (%)	Survey Logistic OR (95 % C.I.)	Survey Logistic OR* (95 % C.I.)	Cox Model RR (95 % C.I.)	Cox Model RR (95 % C.I.)	Multi-level Logistic MLOR (95 % C.I.)
Sex						
Male	51.6	1.19*** (1.05,1.36)	1.16*** (1.04,1.30)	1.18*** (1.07,1.31)	1.18*** (1.06,1.30)	1.20** (1.04,1.39)
Female (Ref)	48.5	1.00	1.00	1.00	1.00	1.00
Mother's age at birth						
< 18 years	3.6	1.25 (0.88,1.77)	1.21 (0.89,1.60)	1.25 (0.96,1.63)	1.28* (0.98,1.67)	1.36 (0.92,2.00)
18-19 years	5.9	0.88 (0.65,1.19)	0.89 (0.68,1.16)	0.99 (0.77,1.28)	1.01 (0.79,1.30)	0.85 (0.59,1.21)
20-24 (Ref)	25.7	1.00	1.00	1.00	1.00	1.00
25-29	27.4	0.99 (0.81,1.20)	0.99 (0.83,1.17)	0.99 (0.85,1.15)	1.01 (0.87,1.17)	1.01 (0.81,1.27)
30-34	21.0	1.04 (0.84,1.29)	1.03 (0.86,1.24)	1.02 (0.85,1.21)	1.04 (0.87,1.23)	1.11 (0.85,1.44)
35 +	16.3	1.19 (0.91,1.56)	1.16 (0.92,1.45)	1.21* (0.99,1.47)	1.25** (1.02,1.52)	1.35* (0.99,1.85)
Previous Birth Interval						
< 18 month	26.1	2.43*** (2.03,2.90)	2.10*** (1.82,2.40)	2.09*** (1.83,2.38)	1.98*** (1.73,2.25)	2.60*** (2.15,3.14)
18-23 month	18.5	1.19* (0.98,1.44)	1.19* (0.98,1.44)	1.19** (1.01,1.39)	1.16* (0.99,1.36)	1.20 (0.95,1.50)
24-35 month (Ref)	32.2	1.00	1.17* (0.98,1.37)	1.00	1.00	1.00
36+ month	23.2	0.69*** (0.55,0.87)	0.71*** (0.58,0.88)	0.69*** (0.59,0.81)	0.70*** (0.59,0.82)	0.67*** (0.52,0.86)
Previous Child Survived to Birth of Index Child						
Yes (Ref)	90.0	1.00	1.00	1.00	1.00	1.00
No	10.0	1.68*** (1.42,1.99)	1.59*** (1.38,1.82)	1.57*** (1.36,1.81)	1.59*** (1.38,1.84)	1.11 (0.90,1.37)
Birth Order X Previous Deaths						
B2-3 X 0 death (Ref)	33.1	1.00	1.00	1.00	1.00	1.00
B4-6 X 0 death	25.9	0.87 (0.71,1.06)	0.88 (0.74,1.05)	0.91 (0.78,1.07)	0.91 (0.78,1.07)	0.92 (0.73,1.16)
B7+ X 0 death	9.7	0.81 (0.57,1.15)	0.83 (0.60,1.13)	0.83 (0.66,1.06)	0.84 (0.66,1.06)	0.87 (0.61,1.24)
B2-3 X 1 death	2.5	1.66** (1.10,2.50)	1.54** (1.09,2.11)	1.56*** (1.17,2.08)	1.56*** (1.16,2.08)	1.75** (1.13,2.70)
B4-6 X 1 death	9.8	1.35** (1.04,1.76)	1.29** (1.03,1.61)	1.36*** (1.12,1.64)	1.32*** (1.09,1.59)	1.23 (0.93,1.62)
B7+ X 1 death	7.1	1.08 (0.78,1.50)	1.07 (0.80,1.41)	1.10 (0.87,1.40)	1.09 (0.86,1.40)	1.08 (0.75,1.54)
B4-6 X 2+ deaths	3.4	1.31 (0.89,1.93)	1.26 (0.90,1.73)	1.45*** (1.11,1.89)	1.40** (1.08,1.82)	0.90 (0.60,1.36)
B7+ X 2+ deaths	8.6	1.24 (0.9,1.72)	1.20 (0.91,1.58)	1.35*** (1.09,1.67)	1.30** (1.05,1.62)	0.96 (0.68,1.35)
Area of Residence						
Urban (Ref)	33.4	1.00	1.00	1.00	1.00	1.00
Rural	66.6	0.96 (0.81,1.15)	0.96 (0.83,1.13)	1.00 (0.88,1.13)	0.97 (0.86,1.1)	0.86 (0.67,1.10)

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Table A4 Sudan (1992/93): Comparative Results for Survival to age 5 of Higher-Order Births ....*(Continued)*

Correlates		N=8498	Survey Logistic		Cox Model		Multi-level Logistic
		(%)	OR (95 % C.I.)	OR* (95 % C.I.)	RR (95 % C.I.)	RR (95 % C.I.)	MLOR (95 % C.I.)
Mother attended School							
No		70.4	1.39*** (1.12,1.72)	1.34*** (1.11,1.61)	1.30*** (1.12,1.51)	1.28*** (1.10,1.49)	1.49*** (1.17,1.90)
Yes	(Ref)	29.6	1.00	1.00	1.00	1.00	1.00
Husband attended School							
No		40.4	1.37*** (1.12,1.67)	1.32*** (1.11,1.56)	1.26*** (1.10,1.43)	1.23*** (1.08,1.40)	1.43*** (1.16,1.77)
Yes	(Ref)	59.6	1.00	1.00	1.00	1.00	1.00
Husband in Agriculture							
No		42.6	1.00	1.00	1.00	1.00	1.00
Yes	(Ref)	57.4	1.06 (0.91,1.24)	1.05 (0.92,1.20)	1.01 (0.90,1.14)	1.02 (0.91,1.14)	1.01 (0.82,1.23)
Years Before Survey							
0-4					0.95 (0.82,1.08)	0.98 (0.86,1.13)	
5-9	(Ref)	55.2	1.00	1.00	1.00	1.00	1.00
10-14		44.8	0.95 (0.83,1.1)	0.96 (0.85,1.08)	0.97 (0.86,1.09)	0.96 (0.85,1.08)	0.98 (0.84,1.15)
Extra Sibling Deaths							
None	(Ref)	97.3				1.00	
1 Extra deaths		2.7				3.57*** (2.8,4.57)	
Status Subsequent Birth							
0 = None	(Ref)	54.4				1.00	
1 = Conception		22.6				1.77*** (1.48,2.12)	
2 = Birth		21.2				1.81*** (1.41,2.32)	
3 = Death		1.8				3.48*** (2.42,5.00)	
Clusters' Utility							
Electricity	(Ref)	30.1					1.00
None		69.9					0.91 (0.68,1.23)
Clusters' Sanitation							
Toilet/Shared	(Ref)	4.7					1.00
Pit/Latrine		63.2					1.74* (0.93,3.27)
Open-Air/Other		32.1					1.71* (0.97,3.03)
Clusters' Water Supply							
Gover-Piped	(Ref)	31.7					1.00
Well/Pumped		49.7					1.55** (1.09,2.20)
Other		18.6					1.19 (0.89,1.60)

Table A5 Yemen (1991/92): Comparative Results for Survival to age 5 of First-Births

Correlates (%)	N=2391 (%)	Survey Logistic OR (95 % C.I.)	Survey Logistic OR* (95 % C.I.)	Cox Model RR (95 % C.I.)	Cox Model RR (95 % C.I.)	Multi-level Logistic MLOR (95 % C.I.)
Sex						
Male	51.0	1.34** (1.07,1.69)	1.28** (1.06,1.53)	1.34*** (1.13,1.59)	1.34*** (1.13,1.59)	1.30** (1.03,1.63)
Female (Ref)	49.0	1.00	1.00	1.00	1.00	1.00
Mother's age at birth						
< 18 years	33.3	1.30* (0.99,1.70)	1.24* (0.99,1.54)	1.33*** (1.08,1.64)	1.33*** (1.08,1.64)	1.33** (1.00,1.76)
18-19 years	19.5	0.95 (0.67,1.35)	0.96 (0.71,1.28)	1.09 (0.85,1.41)	1.09 (0.85,1.41)	0.96 (0.68,1.35)
20-24 (Ref)	31.6	1.00	1.00	1.00	1.00	1.00
25-29	9.7	0.74 (0.48,1.14)	0.77 (0.52,1.12)	0.90 (0.64,1.26)	0.90 (0.64,1.26)	0.73 (0.46,1.16)
30-34	4.2	1.42 (0.86,2.35)	1.33 (0.88,1.95)	1.32 (0.88,2.00)	1.32 (0.87,2.00)	1.38 (0.80,2.38)
35 +	1.7	0.80 (0.24,2.65)	0.83 (0.27,2.11)	1.11 (0.51,2.39)	1.11 (0.52,2.39)	0.71 (0.20,2.54)
Area of Residence						
Urban Ref)	22.7	1.00	1.00	1.00	1.00	1.00
Rural	77.3	1.08 (0.73,1.61)	1.07 (0.76,1.49)	1.09 (0.83,1.44)	1.09 (0.83,1.44)	0.67 (0.41,1.09)
Mother attended School						
No	85.5	1.52 (0.89,2.58)	1.44 (0.9,2.22)	1.43* (0.99,2.05)	1.43* (0.99,2.06)	1.33 (0.84,2.10)
Yes (Ref)	14.5	1.00	1.00	1.00	1.00	1.00
Husband attended School						
No	74.3	1.08 (0.81,1.45)	1.07 (0.83,1.37)	1.14 (0.92,1.41)	1.14 (0.92,1.41)	1.05 (0.79,1.41)
Yes (Ref)	25.7	1.00	1.00	1.00	1.00	1.00
Husband in Agriculture						
No	60.9	1.00	1.00	1.00	1.00	1.00
Yes (Ref)	39.1	1.42*** (1.09,1.86)	1.34*** (1.08,1.66)	1.29*** (1.07,1.56)	1.29*** (1.07,1.56)	1.45*** (1.10,1.90)
Years Before Survey						
0-4				0.52*** (0.40,0.67)	0.52*** (0.4,0.67)	1.00
5-9 (Ref)	48.7	1.00	1.00	1.00	1.00	1.09 (0.86,1.37)
10-14	51.3	1.12 (0.86,1.46)	1.10 (0.88,1.36)	1.05 (0.87,1.27)	1.05 (0.87,1.27)	

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Table A5 Yemen (1991/92): Comparative Results for Survival to age 5 of First-Births................................*(Continued)*

Correlates (%)	N=2391 (%)	Survey Logistic OR (95 % C.I.)	Survey Logistic OR* (95 % C.I.)	Cox Model RR (95 % C.I.)	Cox Model RR (95 % C.I.)	Multi-level Logistic MLOR (95 % C.I.)
Status Subsequent Birth						
0 = None (Ref)	50.3				1.00	
1 = Conception	24.3				0.92 (0.66,1.29)	
2 = Birth	22.5				0.84 (0.47,1.51)	
3 = Death	2.9				1.17 (0.48,2.83)	
Clusters' Utility						
Electricity (Ref)	50.3					1.00
None	49.1					1.11 (0.8,1.54)
Clusters' Sanitation						
Toilet (Ref)	16.2					1.00
Pit/Latrine	42.0					2.05** (1.18,3.54)
Open-Air/Other	41.8					2.10** (1.14,3.85)
Clusters' Water Supply						
Gover-Piped (Ref)	38.6					1.00
Well/Pumped	43.3					0.99 (0.68,1.44)
Other	18.1					1.03 (0.66,1.59)
	100.0					

***=sig. (0.001) , **=sig. (0.05), *=sig. (0.1)

OR* = are the transformed svy-logistic Odds Ratios using formulae on page 123.

Table A6 Yemen (1991/92): Comparative Results for Survival to age 5 of Higher-Order Births

Correlates (%)	N=12703 (%)	Survey Logistic OR (95% C.I.)	Survey Logistic OR* (95% C.I.)	Cox Model RR (95 C.I.)	Cox Model RR (95 C.I.)	Multi-level Logistic MLOR (95 C.I.)
Sex						
Male	52.0	1.12* (1.00,1.27)	1.10* (1.00,1.22)	1.12*** (1.03,1.21)	1.12*** (1.03,1.21)	1.13** (1.01,1.26)
Female (Ref)	48.0	1.00	1.00	1.00	1.00	1.00
Mother's age at birth						
< 18 years	4.3	1.10 (0.85,1.41)	1.08 (0.87,1.32)	1.17 (0.97,1.41)	1.16 (0.96,1.40)	1.08 (0.84,1.40)
18-19 years	6.9	0.91 (0.72,1.16)	0.92 (0.75,1.13)	1.02 (0.87,1.21)	1.02 (0.87,1.21)	0.92 (0.74,1.15)
20-24 (Ref)	26.4	1.00	1.00	1.00	1.00	1.00
25-29	26.5	0.88* (0.77,1.01)	0.90* (0.80,1.01)	0.94 (0.84,1.05)	0.94 (0.84,1.05)	0.86** (0.74,10)
30-34	18.7	0.85* (0.72,1.01)	0.87* (0.75,1.01)	0.94 (0.83,1.07)	0.94 (0.83,1.07)	0.84* (0.70,10)
35 +	17.3	0.96 (0.77,1.18)	0.97 (0.8,1.15)	0.97 (0.83,1.12)	0.97 (0.83,1.12)	0.94 (0.75,1.18)
Previous Birth Interval						
< 18 month	44.8	2.80*** (2.35,3.34)	2.12*** (1.87,2.38)	2.48*** (2.18,2.82)	2.46*** (2.16,2.79)	2.87*** (2.43,3.39)
18-23 month	17.5	1.59*** (1.29,1.96)	1.39*** (1.17,1.63)	1.54*** (1.32,1.80)	1.53*** (1.32,1.79)	1.62*** (1.33,1.99)
24-35 month (Ref)	20.8	1.00	1.00	1.00	1.00	1.00
36+ month	16.9	0.58*** (0.45,0.75)	0.58*** (0.46,0.73)	0.75*** (0.63,0.90)	0.75*** (0.63,0.90)	0.63*** (0.49,0.81)
Previous Child Survived to Birth of Index Child						
Yes (Ref)	85.4	1.00	1.00	1.00	1.00	1.00
No	14.6	1.89*** (1.62,2.21)	1.69*** (1.49,1.90)	1.78*** (1.62,1.96)	1.78*** (1.62,1.96)	1.64*** (1.43,1.88)
Birth Order X Previous Deaths						
B2-3 X 0 death (Ref)	32.3	1.00	1.00	1.00	1.00	1.00
B4-6 X 0 death	22.8	0.76*** (0.64,0.9)	0.79*** (0.68,0.91)	0.79*** (0.70,0.90)	0.79*** (0.69,0.90)	0.79*** (0.67,0.94)
B7+ X 0 death	5.7	0.69** (0.49,0.97)	0.72** (0.53,0.97)	0.60*** (0.47,0.76)	0.60*** (0.47,0.76)	0.75* (0.55,1.04)
B2-3 X 1 death	3.1	1.32* (0.98,1.77)	1.26* (0.98,1.59)	1.29** (1.06,1.56)	1.29** (1.06,1.56)	1.45*** (1.10,1.92)
B4-6 X 1 death	11.5	1.27** (1.05,1.52)	1.22** (1.04,1.41)	1.26*** (1.10,1.44)	1.25*** (1.09,1.43)	1.30*** (1.08,1.56)
B7+ X 1 death	6.3	1.21* (0.97,1.52)	1.17* (0.97,1.41)	1.07 (0.88,1.29)	1.05 (0.87,1.27)	1.23 (0.94,1.61)
B4-6 X 2+ deaths	5.7	1.03 (0.79,1.33)	1.03 (0.82,1.27)	1.09 (0.91,1.30)	1.09 (0.91,1.30)	1.02 (0.8,1.31)
B7+ X 2+ deaths	12.5	1.31** (1.04,1.64)	1.25** (1.03,1.50)	1.28*** (1.11,1.49)	1.27*** (1.09,1.46)	1.28** (1.04,1.58)
Area of Residence						
Urban (Ref)	23.4	1.00	1.00	1.00	1.00	1.00
Rural	76.6	1.06 (0.87,1.3)	1.05 (0.89,1.25)	1.04 (0.93,1.17)	1.04 (0.93,1.17)	1.27* (0.97,1.66)

................................*(Continues next page)*

Table A6 Yemen (1991/92): Comparative Results for Survival to age 5 of Higher-Order Births........................*(Continued)*

Correlates	N=12703 (%)	Survey Logistic OR (95 % C.I.)	OR* (95% C.I.)	Cox Model RR (95% C.I.)	RR (95 % C.I.)	Multi-level Logistic MLOR (95% C.I.)
Mother attended School						
No	94.1	1.27 (0.93,1.73)	1.24 (0.94,1.61)	1.40*** (1.11,1.76)	1.40*** (1.11,1.76)	1.23 (0.91,1.65)
Yes (Ref)	5.9	1.00	1.00	1.00	1.00	1.00
Husband attended School						
No	68.0	1.24*** (1.07,1.45)	1.21*** (1.06,1.38)	1.17*** (1.04,1.32)	1.17*** (1.04,1.31)	1.23** (1.04,1.45)
Yes (Ref)	32.0	1.00	1.00	1.00	1.00	1.00
Husband in Agriculture						
No	75.7	1.00	1.00	1.00	1.00	1.00
Yes (Ref)	24.3	1.12 (0.98,1.28)	1.10 (0.98,1.23)	1.03 (0.95,1.13)	1.03 (0.94,1.13)	1.09 (0.95,1.24)
Years Before Survey						
0-4				0.69*** (0.61,0.77)	0.69*** (0.61,0.77)	
5-9 (Ref)	57.8	1.00	1.00	1.00	1.00	1.00
10-14	42.2	1.29*** (1.14,1.45)	1.24*** (1.12,1.36)	1.17*** (1.07,1.29)	1.17*** (1.06,1.28)	1.33*** (1.19,1.49)
Extra Sibling Deaths						
None (Ref)	97.5				1.00	
1 Extra deaths	2.5				2.60*** (2.07,3.27)	
Status Subsequent Birth						
0 = None (Ref)	54.3				1.00	
1 = Conception	22.8				1.04 (0.91,1.19)	
2 = Birth	21.0				0.72*** (0.58,0.89)	
3 = Death	1.9				1.18 (0.84,1.65)	
Clusters' Utility						
Electricity (Ref)	52.4					1.00
None	47.7					1.33*** (1.11,1.58)
Clusters' Sanitation						
Toilet (Ref)	16.9					1.00
Pit/Latrine	41.6					1.21 (0.91,1.6)
Open-Air/Other	41.5					1.30 (0.95,1.78)
Clusters' Water Supply						
Gover-Piped (Ref)	40.4					1.00
Well/Pumped	40.9					0.99 (0.81,1.21)
Other	18.7					0.97 (0.77,1.23)
	100.0					

***=sig. (0.001) , **=sig. (0.05), *=sig. (0.1) OR* = are the transformed svy-logistic Odds Ratios using formulae on page 121.