Determinants of Infant and Under-Five Mortality – The Case of Jordan

Technical note, February 2010

Cornelia Kaldewei[*,†]

Abstract

Infant and under-five mortality in Jordan have decreased steadily over the last two decades, reaching 21 and 24 per 1,000 live births in 2007, respectively. In spite of this progress, additional efforts will be required to achieve the Millennium Development Goal of reducing under-five mortality by two thirds by 2015, compared to its level in 1990. This technical note examines the determinants of infant and under-five mortality in Jordan, and makes policy recommendations on how to achieve that goal. The presented work was undertaken within the framework of UN-DESA's Development Account Project on "Realizing the Millennium Development Goals through socially inclusive macroeconomic policies". In addition to analysing the determinants of infant and under-five mortality in Jordan, the note also provides a detailed discussion of the estimation methodology, in order to facilitate similar exercises for other countries which are part of this project.

[*] Economic Affairs Officer at the Development Policy and Analysis Division of the United Nations Department of Economic and Social Affairs (DPAD/UN-DESA). Comments are welcome and can be addressed to the author by email (kaldewei@un.org). The views and opinions expressed here are those of the author and do not necessarily reflect those of the United Nations or its Member States.

[†] This technical note is based on a joint paper with Ingo Pitterle on the determinants of infant mortality in Jordan (forthcoming).

1. Introduction

This technical note examines the determinants of infant and child mortality in Jordan, and describes the employed logit estimation procedure, as well as an alternative survival analysis approach. The analysis is based on the 2007 Jordan Population and Family Health Survey (JPFHS), which is part of the worldwide Demographic and Health Surveys (DHS) Program. Similar surveys for many countries are available from the DHS home page (http://www.measuredhs.com).

The note was developed as part of the technical backstopping which the Development Policy and Analysis Division of the United Nations Department of Economic and Social Affairs (DPAD/UN-DESA) provides to national teams – consisting of researchers and policy makers – who participate in the capacity building project "Realizing the Millennium Development Goals through socially inclusive macroeconomic policies". This project is also benefiting from close collaboration with the United Nations Development Programme and the World Bank. The econometric analysis presented in this note is designed to suit the calibration requirements of the economy-wide modelling system that is used in the project for assessing the impact of MDG-related policies and their macroeconomic trade-offs, known as the *Maquette* for MDGs simulation (MAMS).[1]

In MAMS' MDG-specific module, MDG 4 – reducing child mortality – is modelled by the under-five mortality rate[2], as determined by a specific set of variables. These include: access to safe drinking water and to basic sanitation (targets related to MDG 7, environmental sustainability); household consumption per capita; per capita spending on public health services; and a country's stock of "other public infrastructure" that is not directly related to the MDG sectors of education, health, and water and sanitation. The effect of these variables on the under-five mortality rate is captured by a set of elasticities used to calibrate the country specific version of MAMS. These variables, as well as additional control variables, are used as determinants in the econometric analysis of infant mortality in Jordan, presented in the remainder of this note.

The remaining sections are organized as follows: Section 2 gives a general overview of the determinants of infant and under-five mortality, while section 3 provides background information on Jordan's health sector and child mortality trends. Section 4 discusses in detail the employed estimation methodology, and section 5 presents the empirical results. Section 6 concludes.

2. Determinants of child mortality: an overview, and definitions for Jordan

[1] MAMS is an innovative type of dynamic computable general equilibrium (CGE) model that has been designed by the World Bank to analyse the impact of public investments and interventions on MDG achievements, sectoral economic growth, and employment, among other potential areas of analysis. This model has been extended through its application in 18 countries in the Latin American and Caribbean region. The model and results from its application for these countries can be found in: Marco V. Sánchez, Rob Vos, Enrique Ganuza, Hans Lofgren, and Carolina Díaz-Bonilla (eds), Public Policies for Human Development. Feasible Financing Strategies for Achieving the MDGs in Latina America and the Caribbean, London: Palgrave Macmillan (forthcoming).
[2] MDG 4 is quantified as a reduction, between 1990 and 2015, of under-five mortality rates by two thirds.

Following the analytical framework developed by Mosley and Chen (1984), the literature on infant and child mortality has established a number of individual and socioeconomic characteristics that influence the probability of early childhood death. These determinants can be grouped into three categories: a child's personal and biological characteristics; behavioural characteristics of the child's mother; and socioeconomic household and community characteristics. While all determinants specified by MAMS fall into the third category, the first and second categories contain important control variables that are likely to also have central policy implications in their own right. Including those control variables also allows us to avoid omitted variable biases in the estimation. Table A.1 in the annex provides an overview of all determinants used in this study and described in the below.

2.1. Personal and biological characteristics

A child's sex has been shown to affect the probability of infant and child mortality: Owing to biological factors, male infants have a higher risk of mortality during the first year of life, as highlighted for example in WHO (2003a). In addition, differential treatment of boys and girls, owing to cultural and socioeconomic factors, may also be expected to affect the chances of survival during childhood. We therefore include a dummy variable in our estimation to control for the effect of a child's sex.

Premature delivery is another major biological factor causing an increase in the probability of infant and particularly neonatal mortality. While no direct measurement for this variable is available in the 2007 JPFHS data, we use birth weight as a proxy, assuming that premature birth is closely correlated with low birth weight. We do this by introducing a dummy for low birth weight with a cut-off value of 2500 grams, in line with the WHO definition of low birth weight (WHO, 2005).

An additional risk factor for an infant's survival is being born as part of a multiple delivery. We control for this factor by including a dummy for multiple delivery.

Birth order may also play a role in the probability of infant and child mortality, though the direction of the effect is a priori ambiguous. According to the hypothesis of intra-household resource competition, first born children are more likely to capture vital resources such as food and care, thereby reducing their mortality risk (see e.g. Vos et al., 2004). On the other hand, it has been found that first born children, who are more likely to be born to mothers at younger reproduction ages, experience a higher mortality risk than children of a higher birth order. A number of studies indeed point to a U-shaped effect of birth order, with the probability of infant mortality declining after the first child and increasing again for children of birth order four and higher (see e.g. Titaley et al., 2008 and Uddin and Hossain, 2008). To account for this effect, we construct two dummies: one for first born children, and one for children with birth order 4 and higher.

A short preceding birth interval has also been found to increase the probability of infant mortality, resulting in a WHO recommendation of at least 24 month spacing between a preceding birth and a new pregnancy (WHO, 2006b). Assuming a full pregnancy of nine months, this translates into an optimal spacing of 33 months between succeeding births. We use a dummy to control for preceding birth intervals shorter than that.

Finally, we also include a dummy variable for different years of birth, to capture the changes in mortality over time. This dummy takes on the value 1 for all children born between 1971 and 1987, 2 for all children born between 1988 and 1997, and 3 for all children born between 1998 and 2007 (i.e. during the 10-year interval before the survey). In line with improving health conditions over time, we expect a higher value of the dummy to be associated with lower mortality rates.

2.2. Behavioural characteristics

Smoking is a behavioural factor that affects both the mother's health status – and thus indirectly the probability of infant and child mortality – as well as the probability of infant and child mortality directly. We lump together different forms of tobacco smoking, including both cigarettes and *nargila* (water pipe) into one dummy variable to capture this effect. One caveat here is that this variable captures the mother's smoking behaviour at the time of the survey, and it can only be conjectured that this behaviour was the same during pregnancy and/or early childhood, when it would have the strongest impact on the child's health.

Other relevant behavioural characteristics are more directly linked to pregnancy and childbirth, such as the use of private or public healthcare, which we reflect by using a dummy for different types of place of delivery. This distinction is in line with the one used by Vos et al. (2004), who control for private and public health care during delivery. It is not a priori clear that one or the other type of facility should have a beneficial effect on infant mortality, depending rather on the quality of service in each.

Pre-natal controls are expected to improve maternal health and reduce the risk of infant mortality. In this vein, WHO guidelines on prenatal care in developing countries recommend at least four prenatal visits (Berg, 1995). We therefore include a dummy variable to control for this effect.

Breastfeeding has long been recognized as a major determinant of infant and child health, with a shorter breastfeeding period increasing the risk of infant mortality. This is in spite of the presence of potential confounding factors and reverse causation bias – i.e. the truncation of breastfeeding by the death of an infant and the resulting inverse causality between short breastfeeding periods and infant mortality – as highlighted for example by Palloni and Millman (1986). In fact, Habicht et al. (1986) and later Lantz et al. (1992) and others have since convincingly argued that even when such effects are accounted for, the empirical evidence in favour of breastfeeding is overwhelming. Following the WHO recommendation of a minimum of 6 months exclusive breastfeeding (WHO, 2003b), we define a dummy variable which takes the value 1 if the child has been breastfed for less than 6 months and 0 otherwise. To rule out reverse causation, we also set the variable equal to 0 if the child in question dies before the age of 6 months but has been breastfed up to its age at death (in full months). Finally, we drop all observations for which a child dies at the age of less than one full month and (hence) is breastfed for less than one full month. The one month cut-off is owed to the structure of the data in the 2007 JPFHS survey, which only provides age and duration of breastfeeding in full months. As a major drawback, this forces us to drop all cases of neonatal mortality if we want to assess the impact of lactation on infant mortality.

2.3. Household and community characteristics

One of the determinants explicitly modelled in MAMS, access to safe drinking water, is generally accepted as one of the most important household characteristics to reduce infant and child mortality (see e.g. WHO, 2005), and we include a dummy to account for this effect.

The second explicit MAMS determinant, access to improved sanitation facilities, is similar to safe drinking water in that it helps prevent diseases and in turn reduces the probability of infant and child mortality (see e.g. WHO, 2005), and we use another dummy to capture this effect.

Separately from drinking water and sanitation, overall socioeconomic status or living standard is expected to affect the wellbeing of household members, including that of mothers and children. Typically used measurements for this are household income or consumption expenditures per capita (see e.g. and Deaton and Zaidi, 1999). However, while MAMS uses per capita household consumption as an explicit determinant, this information is not included in the 2007 JPFHS data. Unfortunately for our purposes, this lack of data on consumption expenditures or household income is standard for DHS surveys. Instead, the survey data contain a large set of information on assets owned by household members and on housing characteristics. This information can in turn be used to create a wealth index that serves as a proxy for household wealth and thus for long-run socioeconomic status. Following the principal components approach suggested by Filmer and Pritchett (2001), DHS data now routinely include such an index, allowing a ranking of households by relative wealth.[3] We include this wealth index in our analysis to control for the effects of relative household wealth on infant and child mortality outcomes.

As an additional explicit MAMS determinant and central policy variable, we also include per-capita expenditure on public health services in our estimation. Since no information on public spending is included in the 2007 JPFHS data (nor in any standard DHS survey), we use information provided by the Ministry of Finance on public health spending by governorate for 2006. We divide this spending by the respective population in each governorate as estimated by Jordan’s Department of Statistics at year end of 2007. We then use the ratio of per-capita health spending by governorate and the national per-capita health spending as our variable for relative public spending on health services (this normalization makes it easier to interpret results of a standard logistic regression,

[3] While Montgomery et al. (2000) find that a wealth index is not a good proxy for household income, it has in turn been shown to outperform traditional income and expenditure measures in terms of explaining differences in a broad set of health indicators (Rutstein and Johnson, 2004).

especially with a view to the marginal effects). Overall, we would expect higher public spending to be associated with better health outcomes. However, if spending is targeted at under-performing governorates, this would cause the reverse association, especially since the positive outcomes of many health interventions are likely to be felt only with a time lag after the initial spending.

In order to assess the effect of "other public infrastructure" as specified by MAMS, we have a number of choices, to account for all other public infrastructure not pertaining to education, health and water and sanitation. The preferred option would be some combination of indicators for public electricity provision and/or transport infrastructure, including public roads, bridges, airports, etc. Since the 2007 JPFHS (or any standard DHS survey) does not contain information on public transport infrastructure, and less than one percent of children covered in the Jordanian survey come from households with no access to electricity, we use a third alternative: We define a dummy variable that takes the value 1 if a household has continuous access to water all day and 0 if it experiences interruptions in service. A pattern of interrupted service could be interpreted as a sign of poor/insufficient public water management and infrastructure, and we would therefore expect a continuous access to water to have a mitigating impact on infant and child mortality.

We also use dummies to take into account the location of the household, in order to control for possible differences in health outcomes in the rural or urban context, as well as for regional differences between the Central, North and South regions of the country[4]. Further, the data also allow us to differentiate between households in the Badia (desert or semi-desert) and non-Badia areas.

The total number of household members (household size) has also been found to influence infant and child mortality. The expected effect of this variable is a priori ambiguous: while a larger number of household members could imply higher fertility levels and a fiercer competition for resources, a larger number of potential caregivers residing in an extended household may in fact decrease the risk of mortality. Results from the literature suggest that the latter effect outweighs the former (see e.g. Vos et al., 2004 and Uddin and Hossain, 2008) and we therefore expect an increase in household size to reduce the probability of mortality.

Other household level determinants include the age of the mother at the time of birth. While this is likely to be an important determinant for infant and child mortality, owing to differences in biological health status and in experience as a caregiver, we do not expect to find a linear relationship. In fact, much of the literature points to a J- or U-shaped relationship, with a higher probability of mortality for children of very young mothers and for those born to older mothers (see e.g. Rutstein, 2000 and Uddin and Hossain, 2008). We test for this relationship by grouping mothers by age – defining a dummy for mothers under the age of 20 and one for mothers 30 and older.

[4] The North region includes the governorates Irbid, Jarash, Ajloun and Mafraq; the Central region includes Amman, Zarqa, Balqa and Madaba; and the South region includes Karak, Tafielah, Ma'an and Aqaba.

A further characteristic of the mother which is considered relevant for the probability of infant and child mortality is her education level. The literature findings in this respect suggest that higher education significantly reduces the probability of infant and child mortality (see e.g. WHO 2005). We measure mothers' education achievement by their number of completed years of formal education.

Last but not least, and in line with Vos et al. (2004), we are testing for the impact of a child's immunization status. Since the 2007 JPFHS data only provide this information for living children, we use the average immunization coverage at the district level to measure its effect on mortality risk. For this purpose, we first assess whether each child for which the information is available can be considered "fully vaccinated", assigning the value 1 to fully vaccinated children and 0 to not or not fully vaccinated children.[5] Based on that, we calculate the average immunization coverage at district level, and compare it to the national average coverage. For our analysis, we then create a dummy which differentiates between children in a district with higher vaccine coverage than the national average and those children in a district with lower coverage.

3. The health sector in Jordan

3.1. Human development trends

For a lower-middle income developing country, Jordan has achieved above-average outcomes in terms of human development indicators such as education and health. According to the human development index (HDI) for 2007, the most recent available year, Jordan achieved rank 96 out of a total of 182 countries.[6] In the health and education sub-indices, the country scored higher, ranking 78th in terms of life expectancy at birth, 64th in adult literacy rate, and 62nd in combined primary, secondary and tertiary gross enrolment ratio. This is in spite of a much lower ranking – 107th – in GDP per capita as measured in purchasing power parity.

These overall positive results are diminished by Jordan's less-than-stellar performance in terms of gender. The gender-related development index (GDI), first introduced in the Human Development Report 1995, uses the same sub-indices as the HDI, but takes into account differences between women and men. Using the ratio between GDI and HDI to rank countries according to gender disparities relegates Jordan to rank 145. Jordan's rank drops significantly both in terms of life expectancy at birth and of adult literacy rate, but it performs relatively well in terms of combined enrolment ratio, where it slips only from rank 62 to rank 63. This bodes well for future adult literacy rates and possibly also for future infant and maternal mortality outcomes.

---

[5] In line with Department of Statistics and Macro International Inc. (2008), we consider children as fully vaccinated when they have received, at the age of 12 months: (i) one vaccination against tuberculosis; (ii) three doses of dpt vaccine – against diphtheria, pertussis and tetanus; (iii) three doses of polio vaccine; (iv) one vaccination against measles.

[6] The human development index (HDI) has been compiled by the United Nations Development Programme (UNDP) on a regular basis since 1990. It combines different measures of development and well-being into one index number, allowing an assessment of development that goes beyond pure measures of income. The most recent report came out in 2009.

Jordan's past public spending on education and health, as well as other social spending, has been instrumental in achieving the described development outcomes. According to the Human Development Report of 2007/08 – the most recent one to display these numbers for Jordan – the government spent 20.6 per cent of its budget on education in 2001, equivalent to 4.9 per cent of GDP. This is reflected in a combined primary, secondary and tertiary gross enrolment ratio of 78.7 per cent (in 2007). Public spending on health was equivalent to 5.3 per cent of GDP in 2007, supporting a relatively well-developed nationwide public healthcare system, with 1,392 primary healthcare centres and 43 hospitals (as of 2007). An additional 3.8 per cent of GDP in private health spending contributes further to Jordan's healthcare coverage, including through a number of world-class facilities that attract patients from the entire Arab world.[7]

3.2. The Health System

Jordan's health system is modern and well-developed, both by regional standards and in comparison to other lower-middle income countries. It consists of three major elements: the public sector, the private sector, and donors. In 2007, these sectors' respective contributions to overall health care financing amounted to 54.9 per cent, 40.2 per cent, and 4.9 per cent (Ministry of Health, 2008).

The public health care sector comprises the Ministry of Health (MOH), the Royal Medical Services (RMS) and a number of smaller university-based programmes.

In addition to running public hospitals and primary healthcare centres, MOH is responsible for organizing and supervising public and private healthcare services, providing health insurance, and establishing and running training facilities for health professionals. The Civil Health Insurance Plan (CHIP) provides health insurance for all civil servants and their dependents, as well as for all children below the age of 6 years, blood donors, the disabled, and all individuals certified as poor. While this covers around 20 per cent of the population, MHO factually also acts as an insurer of last resort, providing highly subsidized services (at 15 to 20 per cent of the cost) at its facilities to all uninsured individuals.[8]

The Royal Medical Services (RMS) is responsible for providing insurance and health services for all military and security personnel and their dependents, including also retired staff as well as staff of the Royal Court, Royal Jordanian Airlines, and others. This covers another 27 per cent of the population, less than 10 per cent of whom are active military and police personnel. RMS runs 11 hospitals and provides mainly secondary and tertiary care services, including through referrals for MOH beneficiaries.

---

[7] Data on spending and hospital coverage are taken from Jordan's Ministry of Health Annual Statistical Book 2008, the most recent issue at the time of writing this note.

[8] The information in this and the following paragraphs is taken mainly from WHO's Health System Profile of Jordan (2006a). All data on health insurance refer to the year 2004.

The main donor financed programme is the United Nations Relief and Work Agency (UNRWA) for Palestine Refugees in the Near East. In addition to health care, it provides education and social security to Palestinian refugees in Jordan. In 2008, a total of 1.1 million refugees sought medical care in UNRWA's 24 primary health care facilities in the country (UNRWA, 2009). Some, but not all of them, are also entitled to medical services from MOH and RMS. Around 11 per cent of the population are covered exclusively by health insurance services provided by UNRWA.

The private sector provides health insurance coverage to 9 per cent of the population. Private insurance is often provided through private firms for their employees, either through self-insurance or through the purchase of private health insurance. In terms of service provision, the private sector runs 60 hospitals, including some of the country's most high tech facilities. Many Jordanians, including those with public coverage, choose to purchase health services privately through direct out-of-pocket payments. Private health care facilities also attract large numbers of foreign patients from neighbouring Arab countries.

Both in terms of health outcomes and accessibility, the Jordanian health system performs well. Health indicators such as life expectancy at birth, infant and child mortality, and maternal mortality rank the country above the average of lower-middle income countries; around 70 per cent of the population are covered by formal health insurance (as of 2004); and the average patient travel time to a public health care centre is 30 minutes.

Owing to its multi-tiered structure, however, the system is suffering from inefficiencies and inequities. A number of these were diagnosed in a joint study by the World Bank and a team of Jordanian experts (World Bank, 1997). Since then, the government has successfully implemented reforms along the lines suggested by the study, such as management improvements, supported by new data bases for a number of health indicators, as well as cost and coverage information; improvements in the equity of access, setting a goal of full formal insurance coverage for all; and improvements of efficiency and clinical effectiveness of service delivery through reforms in the health care payment systems, a comprehensive capital investment strategy, and the development of norms and standards of service delivery.

In spite of these and other reforms, challenges remain. While some of these have to do with an as yet incomplete reform agenda (more than 20 per cent of the population are still lacking insurance cover, and the provision and financing of health services is still suffering from inefficiencies), others are owing to the rapid demographic and life style changes as a consequence of Jordan's economic and social development. These include the expected increase in population, a higher life expectancy and the related increase in the incidence of chronic diseases and non-communicable diseases like cardiovascular diseases, cancer and diabetes, as well as the rapid advance in technology and rising health care costs, combined with increasing demands and expectations of the public.

3.3. Infant and Under-Five Mortality Trends

While MDG 4 calls for a reduction of “child mortality”, the related target is to “reduce by two thirds, between 1990 and 2015, the under-five mortality rate”. Technically, infant mortality and under-five mortality are measured in terms of the number of deaths per 1,000 live births before a child’s first birthday and before its fifth birthday, respectively. Child mortality in turn is technically defined as the rate of deaths between the ages of one and five years, and can be computed as the difference between under-five and infant mortality.

Indicators for infant and under-five mortality rank Jordan at the median level of a total of 194 countries for which comparable data is available. According to the MDG Indicators Database, compiled by the United Nations Statistics Division, Jordan has been able to reduce infant and under-five mortality rates from 33 to 21 and from 40 to 24, respectively, between 1990 and 2007. These numbers are relatively low for a country with Jordan’s per capita income, and compared to a mean infant mortality rate of 35 in 2007 (median 21.5) and a mean under-five mortality rate of 50 (median 24.5). This may, however, make it more difficult to achieve the goal of reducing under-five mortality by two-thirds by 2015, owing to diminishing marginal returns of health interventions as mortality rates decrease (leaving only the most difficult and most costly to treat cases). In addition, while Jordan’s progress was steady, it was slower than in a number of other countries, as reflected in its deteriorating rank (see table 1).

Table 1: Infant and under-five mortality in Jordan and global trends, 1990-2007

Infant mortality (per 1,000 live births)		
Year	**mortality rate (global median, mean)**	**rank (no. of countries)**
1990	33 (41, 51.3)	84 (191)
1995	29 (33, 46.6)	90 (193)
2000	25 (28, 41.7)	90 (194)
2005	22 (23.5, 36.9)	93 (194)
2007	21 (21.5, 35.1)	95 (194)
Under-five mortality (per 1,000 live births)		
Year	**mortality rate (global median, mean)**	**rank (no. of countries)**
1990	40 (51, 74.9)	86 (191)
1995	35 (41, 67.9)	92 (193)
2000	30 (32.5, 60.2)	91 (194)
2005	26 (27.5, 52.7)	95 (194)
2007	24 (24.5, 50.0)	94 (194)

Source: UNSD, MDG Indicators; authors’ calculations

The final report of the 2007 Jordan Population and Family Health Survey (JPFHS) provides a more detailed overview and analysis of these trends at the national and sub-national level (Department of Statistics and Macro International Inc., 2008). Overall, the numbers and trends are compatible with UNSD data, while providing more detail according to different five-year time intervals prior to the survey. Such time intervals can be constructed on the base of reported birth and death dates of children in the survey (the earliest reported date of birth in the 2007 JPFHS was January 1971 and the most recent was September 2007). Table 2 gives an overview of early childhood mortality rates in Jordan by time interval prior to the survey.

Table 2: Early childhood mortality by five-year intervals preceding JPFHS 2007

Years preceding the survey	Neonatal mortality rate[1]	Postneonatal mortality rate[2]	Infant mortality rate	Child mortality rate	Under-five mortality rate
0-4	14	5	19	2	21
5-9	16	5	21	3	24
10-14	15	8	23	3	26
0-9	***15***	***5***	***20***	***2***	***22***

Source: Department of Statistics and Macro International Inc. (2008)

[1] Defined as the number of deaths during the first 28 completed days of life per 1,000 live births

[2] Computed as the difference between the infant and neonatal mortality rates

In addition to the general time trends, table 2 also differentiates further between mortality rates, revealing uneven progress for different age groups. While under-five mortality has declined steadily over the three five-year periods prior to the survey, from 26 to 21 per 1000 life births, this was mainly owing to similar declines in infant mortality. Child mortality, in contrast, has not moved much over time, hovering around 2 or 3 per 1000 life births. In turn, the decline in infant mortality seems to have been driven mostly by the decrease in postneonatal mortality, with neonatal mortality rates not following a clear time trend.

In the country's efforts to further reduce early childhood mortality rates, the focus should therefore be on infant mortality, and especially on neonatal mortality. From a medical point of view, neonatal mortality tends to be more difficult and expensive to reduce, since it includes cases of severe illness and disorders that require more advanced medical treatment. This would, in turn, drive up the overall cost of achieving MDG 4 on time, as argued above. However, preventive care may help reduce the occurrence of those conditions that are caused by behavioural factors such as smoking during pregnancy or insufficient spacing between consecutive births. Such behavioural factors indeed turn out to be important determinants of infant mortality, as discussed in section 5 of this note.

4. Estimation methodology

In this technical note, the focus lies on estimating the determinants of infant mortality, even though MAMS calls for calibration with elasticities for under-five mortality. Two factors lead us to prefer infant mortality for our estimation: First, as described in section 3 above, the main driver of under-five mortality in Jordan is in fact infant mortality. In order to reduce under-five mortality, we must therefore identify the determinants of infant mortality and consider appropriate policy tools for reducing that rate. Second, the estimation of under-five mortality based on the 2007 JPFHS data with a standard logit model does not allow us to include important behavioural variables such as breastfeeding. This is the case because information on breastfeeding is available only for those children who are born within the five year interval before the survey, and the logit model forces us to drop all observations that are not fully at risk, i.e. all children less than five years old and alive at the time of the survey. Overall, given that under-five mortality in Jordan is concentrated during the first year of life, we are confident that the results of our analysis of infant mortality are applicable for under-five mortality. For control purposes, we also run one estimation for under-five mortality, by including all relevant determinants for MAMS as well as a number of control variables (see annex table A.2). As expected, the results are very similar to those for infant mortality, presented in table 4.a in section 5 below.

When analysing infant mortality, the variable of interest is the death or survival by the age of one of each child in the sample. With such a dichotomous variable, the appropriate estimation method would be a logit/probit model, which estimates the probability of dying during a certain time interval, conditional on being alive at the beginning of the interval, and depending on a set of independent variables. One major drawback of such binary choice models is, however, the unavoidable censoring of the data, as those children that are not fully exposed to the mortality risk must be dropped from the sample. Hence, if the variable of interest is infant mortality, all those children that are under one year of age and alive at the time of the survey must be dropped. Similarly, to analyse under-five mortality, all children that are alive and under five years of age at the time of the survey would have to be dropped from the sample. A second drawback is the loss of information that is involved in the arbitrary determination of the time interval in which death may or may not occur: one full year in the case of infant mortality or five full years in the case of under-five mortality.

Another frequently used type of model for analysing infant mortality are the so-called survival analysis or duration models, which allow for the inclusion of censored data and for using the available information about an infant's age in months at time of death. These models specifically take into account the elapsed time before an event such as death occurs, while also allowing for the influence of a set of independent variables. This is done by using a hazard function which measures the probability of death at a given point in time, conditional on survival up to that time and on a vector of exogenous covariates. The often used semi-parametric Cox Proportional Hazard model, first developed by Cox (1972), leaves the time-dependent term of the hazard function – the baseline hazard – unspecified, treating it as an unknown function of time. The model thus avoids the risk of misspecifying the baseline hazard, resulting in more robust estimators than those of parametric duration models. However, while the Cox model does not specify a baseline hazard, it remains restrictive in its assumption of proportional hazard functions, meaning that for each covariate, the ratio of hazards must remain the same for any two observations (individuals) over time. This is a critical assumption, as the mortality risk can be expected to evolve differently over time for different realizations of a covariate. One case in point is the mortality risk associated with the dummy variable for a child's sex: Owing to biological factors, infant boys are prone to a higher mortality risk than infant girls, and particularly so during the first few months of life, which leads us to expect a change in the hazard ratio between the two groups over time.[9]

[9] For a discussion of econometric techniques in health economics, see e.g. Jones (2005).

While both types of models are appropriate and in fact widely used in the literature for analyzing infant mortality[10], we prefer the logit/probit model for two reasons: First, and most importantly, it provides additional insights about variables that violate the proportional hazards assumption. Such variables can only be included in a stratified Cox model, where they are used as stratification variables and not as determinants, so that no coefficients can be computed for them. This is an acceptable way of solving the problem as long as those variables are not of primary interest for the analysis. In our case, however, the dummy variable for male/female children is likely to be an important explanatory factor for infant mortality, and is especially interesting given the observed gender bias in Jordan's human development indicators. Second, the logit/probit model is in general the more widely known estimation method, making it easier to replicate and interpret the results.[11]

We run both logit and probit estimations, and perform link tests for model specification after each run, in order to assess whether the probit model's standard normal distribution or the logit model's logistic distribution better fits our data. The test results indicate that the logit model is a better fit, and we proceed with our estimation using the standard logit regression model, as specified below:

$$\text{Prob}(Y = 1 \mid \mathbf{x}) = \frac{\exp^{\mathbf{x}'\boldsymbol{\beta}}}{1 + \exp^{\mathbf{x}'\boldsymbol{\beta}}} ,$$

where the probability for the realization of the event $Y = 1$ (here: child dies before its first birthday), conditional on the covariate vector $\mathbf{x}$ is determined by the logistic function of the covariate vector $\mathbf{x}$ and the vector of coefficients $\boldsymbol{\beta}$. It follows that the counter probability for the realization of the event $Y = 0$ (the child survives at least until its first birthday), is specified as:

$$\text{Prob}(Y = 0 \mid \mathbf{x}) = \frac{1}{1 + \exp^{\mathbf{x}'\boldsymbol{\beta}}} .$$

As covariates, we use the determinants specified in section 2 above, and described in detail in table A.1 in the annex. Since not all determinants have observations for each individual, including them in the estimation reduces the sample size, and sometimes substantially so. We therefore report on three different estimations for infant mortality:

In estimation (I), we only include determinants with no or very few missing observations, leaving us with the most complete sample size (41,153 observations) and high explanatory power. This estimation includes all determinants that are required for the

[10] In their meta-analysis of determinants of child mortality, Charmarbagwala et al. (2004) compare a total of 38 studies, 21 of which use logit/probit techniques and 18 use hazard models (one paper uses both).
[11] In a separate estimation, we used the stratified Cox Hazard model, yielding results for the non-stratified variables that closely resemble the logit results, both in terms of sign and magnitude, as well as significance levels. The results for are available from the author upon request.

calibration of MAMS: access to safe drinking water and to improved sanitation, as well as household wealth, public spending on health services, and other infrastructure. In addition, we include the following control variables: sex of child, whether or not the child is part of a multiple birth, dummies for birth order and for short preceding birth intervals, number of household members, mother's age, years of mother's education, mother's smoking habit, rural vs. urban household, geographical dummies, and district immunization status. To account for changes in infant mortality over time in this complete sample, we also include the birth interval dummy described in section 2.

In estimation (II), we include two additional variables (premature delivery, and the use of a private facility for delivery) with a large number of missing observations, reducing the sample size by around four fifths (to 8,112 observations). Since all children that are left in this reduced sample were born within the five year interval before the survey, we drop the dummy for the child's birth interval. While most of our previous results remain robust, the outcomes of this estimation must be taken with some caution due to the much smaller sample size. We nonetheless consider it important for its result concerning the impact of premature delivery, which turns out to be an important predictor of infant mortality.

In estimation (III), we drop those variables that are insignificant in estimation (II), and focus our attention on the role of breastfeeding for child survival. As laid out in the description of variables in section 2, we do not include infants that die at less than one month of age, in order to rule out reverse causation. Bearing in mind that we thus effectively drop all cases of neonatal mortality (leaving a total of 7,997 observations), we interpret our results with great caution, but find that breastfeeding is indeed still a major determinant of (postneonatal) infant mortality in Jordan.

Among the list of determinants, some are likely to be correlated, such as household wealth and the mother's education level. To avoid biases in our estimators caused by multicollinearity, we test for pairwise correlation between all determinants. We also follow the suggestion by Berry and Feldman (1985) to regress the determinants against each other to identify correlation. However, we do not find strong correlations between any of our determinants.

We also use the Box-Tidwell test to test for the functional form of all variables, and find that our variable for mother's education should not enter the regression equation linearly, but in its squared form.

Finally, it is worth noting that we do not use sample weights in our logit estimation, even though the 2007 JPFHS data are stratified along geographic and rural/urban lines. While sample weights are required for obtaining unbiased estimators of means and other indicators for descriptive statistics purposes, we follow the argumentation in Wooldridge (2002) and O'Donnell et al. (2008) that when it comes to the econometric analysis of causal relationships, unweighted estimators are consistent and more efficient than their weighted counterparts. This is the case provided that the source of the differences between the sample and the population proportions is not driven by the variable of interest, in this case infant mortality. We are reasonably confident that infant mortality is not strongly influencing domestic migration patterns, and hence prefer the use of unweighted estimators.

5. Descriptive statistics and empirical results

5.1. The data set

The 2007 Jordan Population and Family Health Survey (JPFHS) covers a nationally representative sample of 14,564 households and 10,876 ever-married women aged 15-49, with response rates of 99 and 98 percent, respectively. The sample is designed to produce representative results for the country level, as well as for urban and rural areas, the Badia and non-Badia areas, the North, Central and South region, as well as for all 12 governorates. Since the sample allocation is not strictly proportional to each governorate, weights are attributed at the household and at the individual woman level to ensure representative estimates.[12]

DHS surveys are typically organized in different data sets, reflecting the different units of analysis. In the case of the 2007 JPFHS, this translates into separate data sets for household data, individual woman's data, children's data, and household listing data. For our analysis of the determinants of infant and child mortality, we need the first two of these data sets. While the household file contains a number of relevant household characteristics, such as wealth, access to safe drinking water and sanitation facilities, the individual woman's file contains all relevant information on a woman's complete birth history (in the case of 2007 JPFHS, this includes up to 19 births).

We use information from these two files to construct a comprehensive data set for the analysis of infant and child mortality in Jordan. In those cases where information on the same variable is available in both the household and the individual woman's file, we use the information from the household file, in order to avoid inconsistencies. Based on a total of 10,876 interviewed women with between 0 and 19 children each, we are able to create a comprehensive data set covering the household, maternal and individual characteristics of 43,460 children, born between January 1971 and September 2007.

5.2. Descriptive statistics

Summary statistics based on the 2007 JPFHS data allow us to break down infant and under-five mortality rates according to the determinants in our analysis. While this in itself does not tell us anything about causalities or the exact magnitude of a correlation and its statistical significance, it provides a first overview of the incidence of mortality according to the different characteristics.

In addition to the mortality rates by characteristic, table 3 also shows the prevalence of each characteristic as measured by the percentage of children born during the 10-year period prior to the survey who exhibit this characteristic. All calculations are based on

[12] For a detailed description of the sample design and data collection, see the final report in Department of Statistics and Macro International Inc. (2008).

this 10-year period in order to generate a sufficiently large sample size, while at the same excluding older observations which do not properly reflect current trends. Also, we are not separately reporting mortality rates for determinants that are measured as continuous variables, such as the mother's education level in years and the total number of household members. For household wealth, we report summary statistics for different quintiles. We are not reporting on the mortality rates associated with our dummy for pre-natal controls, since we have less than 7000 observations for this variable, of which only around five per cent report less than the recommended four pre-natal controls; and the bias in the response rate seems very large, yielding overall very low mortality rates. Consequently, we are also dropping this variable from our estimations.

Table 3: Infant and under-five mortality rates by characteristics, for the 10-year interval preceding JPFHS 2007

Characteristic	Prevalence (per cent of all children born 10 years prior to survey)	Infant mortality rate (per 1,000 live births)	Under-five mortality rate (per 1,000 live births)
Personal and biological characteristics			
Infant's/child's sex			
male	51.4%	20	22
female	48.6%	20	23
Premature delivery[1]			
low birth weight	11.0%	50	na
normal birth weight	89.0%	12	na
Multiple delivery			
multiple birth	3.2%	109	110
single birth	96.8%	17	20
Birth order			
first born	21.7%	20	22
2nd or 3rd born	37.7%	18	20
4th born or higher	40.6%	23	25
Preceding birth interval			
less than 33 months	56.1%	25	27
33 months or more	43.9%	17	18
Behavioural characteristics			
Mother smokes tobacco			
smokes	10.8%	33	34
doesn't smoke	89.2%	19	21
Type of delivery facility[1]			
private	34.9%	(19)	na
public	65.1%	(18)	na
Breastfeeding[1]			
less than 6 months	31.3%	(11)	na
6 months or more	68.7%	(3)	na
Household and community characteristics			
Access to drinking water			
improved source	97.5%	20	22
non-improved source	2.5%	30	33
Access to sanitation			
improved	85.1%	19	21
non-improved	14.9%	27	31
Socioeconomic status			
lowest quintiles	46.4%	23	26
middle quintile	20.7%	13	14
higher quintiles	32.9%	20	23
Urban residence			
urban	83.5%	20	22
rural	16.5%	23	27
Badia area			

badia	8.8%	18	21
non-badia	91.2%	20	23
Region			
Central	61.9%	19	21
North	29.1%	21	23
South	9.0%	27	32
Mother's age at birth			
under 20 years	6.1%	36	38
between 20 and 29 years	56.4%	17	19
30 years and above	37.5%	22	24
District immunization status			
above average	58.2%	18	19
below average	41.8%	24	28
Other infrastructure			
household has water all day	91.6%	21	23
hh does not have water all day	8.4%	17	18
Total		**20**	**22**

Source: Department of Statistics and Macro International Inc. (2008); authors' calculations
Note: Figures for private vs. public delivery facility are reported in parenthesis to account for an apparent response bias causing an underreporting of mortality. Mortality figures for breastfeeding are also reported in parentheses as they are significantly biased downwards owing to the omission of neonatal deaths in the breastfeeding variable. na means not applicable.
[1] Data is available only for the last five children born to a mother.
[2] Data is available only for the last child born to a mother.

Among the personal and biological characteristics, there are clear differences in mortality rates according to birth weight (our proxy for premature delivery), multiple deliveries, birth order, and the preceding birth interval. As expected, low birth weight is associated with higher infant mortality, as are being part of a multiple delivery, and being born only a short interval after a preceding birth. Mortality rates also vary with birth order: in line with other findings in the literature, infant mortality is highest for children with birth order four or higher, while it is lowest for children with birth order two or three.

A child's sex does not seem to be associated with infant mortality, though under-five mortality is slightly higher for girls than for boys. This finding is somewhat surprising, as one would expect to see the biological advantage of girls resulting in higher infant mortality for boys. In fact, we find such a relationship when we look at the entire dataset, including all children born between January 1971 and September 2007 instead of just the ten years before the survey: While overall infant and under-five mortality are higher during this longer time period – at 23 and 26 per 1,000 live births, respectively (reflecting the improvements that have taken place over the last thirty years) – the infant mortality rate was 20 per 1,000 live births for girls and 26 for boys, and the under-five mortality was 23 for girls and 29 for boys. This difference in the descriptive statistics thus suggests that boys were the main beneficiaries of recent improvements in mortality rates.

Among the behavioural determinants, we only find meaningful associations for the smoking variable and for breastfeeding, but not for the type of delivery facility (possibly owing to the apparent response bias). According to the statistics, infant mortality is much higher if the mother smokes, and it is lower if an infant has been breastfed for at least six months. Against this backdrop, it is important to note that around 11 per cent of children are born to mothers who report smoking. Also, more than 30 per cent of children are being breastfed for less than six months.

Among the household and community characteristics, we observe higher mortality rates among infants and children who lack access to either safe drinking water or improved sanitation facilities. Importantly, while only 2.5 per cent of children are born into households without an improved source of drinking water, 15 per cent still lack access to improved sanitation facilities. Concerning the mother's age at birth, we find the expected u-shaped relation with infant and under-five mortality. Further, we find that above-average immunization coverage within a district is associated with lower mortality, both at the infant and the under-five level. There are also clear differences in mortality rates according to residence, with lower infant and under-five mortality rates in urban areas, as well as in the central region. In comparison, mortality rates are higher in the northern and highest in the southern region. Interestingly, the data do not show higher mortality rates for the Badia (desert or semi-desert) area.

Our infrastructure dummy does not display the expected positive correlation with lower mortality, suggesting that this may be a weak explanatory variable. Given Jordan's overall development level and infrastructure coverage, our hunch is that "other infrastructure" has no discernible effect on infant and under-five mortality. In fact, in our estimations below, we find the variable to be not significant. One alternative explanation could be that the selected dummy variable is not a sufficiently good proxy for infrastructure.

Using wealth quintiles, we find no clear trend for socioeconomic status. While mortality rates are highest for the lower two quintiles, they are lowest in the middle quintile, and substantively higher in the upper two quintiles. We do find that more children are born to poorer households than to richer households (explaining the overrepresentation of the lower quintiles and under-representation of the higher quintiles in our sample of children). For our estimations below, we use the continuous wealth indicator and find a positive correlation between higher household wealth and lower infant mortality.

5.3. Empirical results

Estimation (I) in table 4.a reports the estimation results for infant mortality for the core set of variables, as discussed in section 4. This estimation is based on the most complete set of observations, including children born between January 1971 and September 2007. It therefore captures the relation between infant mortality and its determinants during a longer time period than the descriptive statistics in table 3 above. When we analyse this relation for the shorter time period of 10 years prior to the survey, our sample size is reduced by more than one half. While this does not greatly affect the direction or the magnitude of the reported coefficients, it does cause a large increase in standard errors, reflecting a loss in efficiency, and leading to generally lower significance levels of our results. Given these drawbacks, and the lack of apparent advantages, we prefer to use the full sample for our analysis.[13]

Table 4.a: Determinants of Infant Mortality in Jordan

	(I)		
	Parameter Estimates	**Marginal Effects**	**Elasticities**
Male	0.207*** (0.063)	0.0044	0.105
Multiple Delivery	1.855*** (0.108)	0.0987	0.042
First born	0.409*** (0.119)	0.0097	0.092
Birth order 4 and higher	0.185** (0.085)	0.0040	0.073
Short preceding birth interval (< 33 months)	0.471*** (0.094)	0.0099	0.251
Mother smokes tobacco	0.440*** (0.089)	0.0111	0.042
Age of mother at birth under 20	0.530*** (0.096)	0.0138	0.058
Age of mother at birth above 30	0.179** (0.089)	0.0040	0.044
Mother's education (years of formal schooling squared)	-0.003*** (0.001)	-0.0001	-0.276
Total number of household members	-0.104*** (0.015)	-0.0022	-0.775
Lack of access to improved source of drinking water	0.406*** (0.153)	0.0104	0.012
Lack of access to improved sanitation	-0.107 (0.080)	-0.0022	-0.022
Wealth index	-0.001** (0.000)	0.0000	-0.010
Urban Residence	0.019 (0.073)	0.0004	0.013
Badia Region	0.072 (0.091)	0.0016	0.011
Central Region	-0.256*** (0.082)	-0.0052	-0.090
Southern Region	0.045 (0.084)	0.0010	0.014
District has higher than average immunization status	-0.083 (0.074)	-0.0017	-0.032
Public health spending by governorate	0.201** (0.089)	0.0043	0.207
Access to water all day	0.020 (0.099)	0.0004	0.017
Year of birth dummy	-0.202*** (0.051)	-0.0043	-0.446

[13] The estimation results for the 10-year time period before the survey are available from the author upon request. While most results indeed remain the same, three differences are worth mentioning, which seem to reflect a change in patterns over time: First, contrary to the full sample, the results of the restricted estimation do not show a significant effect of a child's sex on infant mortality. This is in line with the descriptive statistics shown in table 3. This change reflects a relative improvement for boys, who seem to have benefited more from the overall health improvements of the last decades than girls. Second, the results of the restricted estimation do not show a significant effect for mothers aged less than 20 years at the time of birth. The loss of statistical significance is likely to reflect the strong reduction in the percentage of such young mothers, from 10.8 per cent in the complete sample to 6.1 per cent in the period 10 years prior to the survey (see table 3). Third, the wealth index also loses significance in the restricted estimation, suggesting that household wealth has become a less important determinant of infant mortality over time, likely owing to the overall improvement in access to health care.

Sample size	41,153
LR chi2(21)	478.89
Prob > chi2	0.0000
Pseudo R2	0.0485

Note: All estimations use the largest possible sample, including children born between January 1971 and September 2007. We report parameter estimates, with standard errors given in parentheses, as well as marginal effects and elasticities. *** indicates significance at the 1 per cent level; ** at the 5 per cent level, and * at the 10 per cent level.

Among the personal and biological characteristics, we find that multiple delivery, birth order and preceding birth interval all display the expected signs and are statistically significant at the 1 per cent level (at the 5 per cent level, for birth order four and higher).

Further, we find that male children are at a higher risk of dying before their first birthday. As discussed, this association is not reflected in our descriptive statistics for the ten years prior to the survey, but is in fact pronounced when looking at the complete dataset: in estimation (I), the result comes through as highly significant. However, in estimation (II), this relationship loses significance and the coefficient even changes its sign (see table 4.b). This dramatic change can be solely attributed to the reduction in sample size in estimation (II) caused by the inclusion of the variables on premature delivery and type of delivery facility. As observations for these variables are available only for the last five children born to one mother, the analyzed pool of children is in effect limited to those born during the five-year interval before the survey. We conclude that this observed change in the relationship between an infant's sex and its mortality risk over time reflects the underlying change in Jordan's overall improvements in health care and reduced infant mortality, combined with a cultural preference for boys over girls, which in turn causes boys to benefit relatively more from the improved circumstances. Such a relationship is not uncommon in developing countries, as documented by Fuse and Crenshaw (2006).

For the mother's age at birth, we find the expected U-shaped relationship, with higher risks of infant mortality born to mothers under 20 years and mothers over 30 years old. While the impact of very young mothers' age is strong in estimation (I), as measured by the variable's marginal effect and by its significance level, this effect disappears in estimation (II), where the variable loses significance. The impact of being born to an older mother, in turn, remains significant at the 5 per cent level in estimations (I) and (II), even as the sample size is reduced and only children born during the five-year interval before the survey are included. This phenomenon may be attributable to an underlying change in behavioural patterns, with a relative reduction in the numbers of very young mothers and a relative increase in the number of mothers over the age of 30 (see footnote 13).

As expected, the square of a mother's formal education in years reduces the risk of infant mortality, and is highly significant in all estimation results.

Concerning household size, we find that a larger number of household members decreases the risk of infant mortality, thus supporting the argument of a beneficial effect of a larger number of caregivers, as spelled out in section 2.C.

Among the variables required for the calibration of MAMS, we find that access to safe drinking water is indeed highly significant in estimation (I), and a lack of access increases the risk of infant mortality. As indicated by the reported marginal effects, this risk is one full percentage point higher for children born into a household without access to safe drinking water, as compared to children born into households with safe water access. While only 2.5% of children were affected by this condition in the 10 years prior to the survey (see table 3), this results highlights the importance of universal access in order to reduce infant mortality. However, this variable also loses significance in estimation (II): While it is significant in the estimation for the ten-year period before the survey (see footnote 13), it loses significance for the five-year period before the survey. The lack of access to improved sanitation on the other hand, does not have a statistically significant effect on infant mortality in either estimation, and the coefficient does not show the expected sign.

The wealth index is highly significant in estimation (I) and the sign is as expected, but its marginal effect and elasticity are extremely low. Further, the variable loses significance in estimation (II), in line with the full estimation for the 10-year period prior to the survey. We conclude that household wealth has become a less important determinant of infant mortality over time, likely owing to the overall improvement in access to health care.

Similarly, our infrastructure variable – defined as access to water all day – is not significant in any of the estimations, suggesting that infrastructure is not an important determinant of infant mortality in Jordan.

Public spending on health services, in turn, is significant at the 5 per cent level, but the sign is the opposite of what we would expect – i.e. higher public spending per capita increases infant mortality. Our explanation for this phenomenon is the targeting of under-performing governorates, where higher spending is aimed at improving health outcomes in areas with relatively high infant mortality rates. This causation would explain the observed correlation and would better fit the data: while the survey covers infant mortality between 1971 and 2007, we have data on public health spending available only for 2006. It would be counterintuitive to expect public spending in 2006 to affect infant mortality during the preceding time interval.

Household residence seems to have little impact on infant mortality risks, apart from the effect of the dummy for the Central region (containing the capital, Amman) in estimation (I). Again, this effect does not carry through in estimation (II) and is also not present in the estimation for the 10-year period prior to the survey, suggesting that the area of residence has become a less important determinant over time. Urban residence or a residence outside of the Badia region do not have a significant effect in any of our estimations.

Further, while the immunization status at the district level has the expected sign, it does not have a significant effect on infant mortality in any or our estimations, likely owing to the overall high immunization rates in the country.

The only behavioural variable included in estimation (I) is the mother's smoking status. As expected, the fact that a mother smokes increases the risk of infant mortality, and is highly statistically significant. Based on the estimated marginal effects, the mortality risk is 1.1 percentage points higher for children born to a smoking mother, as compared to children whose mothers do not smoke. Although the variable loses significance in estimation (II), it is significant in the estimation for the ten-year period before the survey, albeit with a slightly smaller coefficient. With eleven per cent of children being born to mothers who smoke (see table 3), this suggests that there is room for improving infant mortality by inducing a change in smoking habits.

In table 4.b, we present the same estimations for enlarged sets of determinants. As discussed above, however, the inclusion of additional potentially important determinants greatly reduces the sample size from 41,153 children in estimation (I) to 8,112 in estimation (II) and only 7,997 in estimation (III). The results of these estimations must therefore be taken with caution.

Table 4.b: Determinants of Infant Mortality in Jordan

	(II)			(III)		
	Parameter Estimates	**Marginal Effects**	**Elasticities**	**Parameter Estimates**	**Marginal Effects**	**Elasticities**
Male	-0.043 (0.170)	-0.0005	-0.021			
Multiple Delivery	1.546*** (0.283)	0.0429	0.040	-0.776 (1.040)	-0.0019	-0.018
First born	0.082 (0.309)	0.0011	0.017	0.034 (0.574)	0.0001	0.007
Birth order 4 and higher	0.431* (0.248)	0.0057	0.181	0.475 (0.432)	0.0017	0.201
Short preceding birth interval (< 33 months)	0.657*** (0.210)	0.0087	0.292	0.751** (0.377)	0.0028	0.337
Mother smokes tobacco	0.226 (0.284)	0.0032	0.015			
Age of mother at birth under 20	0.373 (0.382)	0.0056	0.018	0.340 (0.656)	0.0014	0.017
Age of mother at birth above 30	0.466** (0.208)	0.0062	0.185	0.579 (0.362)	0.0022	0.232
Mother's education (years of formal schooling squared)	-0.004*** (0.001)	-0.0001	-0.569	-0.006** (0.003)	0.0000	-0.773
Total number of household members	-0.258*** (0.058)	-0.0033	-1.649	-0.196** (0.097)	-0.0007	-1.263
Lack of access to improved source of drinking water	0.333 (0.436)	0.0049	0.010			
Lack of access to improved sanitation	0.139 (0.210)	0.0018	0.029			
Wealth index	0.003** (0.001)	0.0000	-0.020	-0.000 (0.002)	0.0000	0.003
Urban Residence	-0.122 (0.199)	-0.0016	-0.082			
Badia Region	-0.205 (0.254)	-0.0024	-0.033			
Central Region	-0.155 (0.216)	-0.0019	-0.056			
South Region	-0.044 (0.237)	-0.0006	-0.013			
District has higher than average immunization status	-0.020 (0.195)	-0.0003	-0.008			
Public health spending by	0.461*	0.0058	0.478			

governorate	(0.249)					
Access to water all day	0.421	0.0045	0.372			
	(0.325)					
Premature delivery	1.101***	0.0215	0.146	0.824**	0.0040	0.108
	(0.191)			(0.339)		
Private delivery facility	-0.011	-0.0001	-0.002	-0.144	-0.0005	-0.032
	(0.230)			(0.420)		
Breastfeeding less than 6 months				1.369***	0.0076	0.291
				(0.308)		
Sample size		8,112			7,997	
LR chi2		118.46			45.61	
Prob > chi2		0.0000			0.0000	
Pseudo R2		0.0810			0.0820	

Note: All estimations use the largest possible sample, including children born between January 1971 and September 2007. We report parameter estimates, with standard errors given in parentheses, as well as marginal effects and elasticities.
*** indicates significance at the 1 per cent level; ** at the 5 per cent level, and * at the 10 per cent level.

The two additional variables included in estimation (II) are the dummy for premature delivery (using low birth weight as a proxy) and the dummy for a private delivery facility. In line with our findings in the descriptive statistics, the coefficient for premature delivery displays the expected sign and is highly statistically significant. As indicated by the estimated marginal effects, the infant mortality risk is 2.2 percentage points higher for children born prematurely, as compared to full-term children. Meanwhile, we find no significant effect for the choice of delivery location – while this may be owing to the response bias apparent in the descriptive statistics, it may also suggest that the Jordanian public health system does not perform at a significantly lower level than the private health sector.

In estimation (III), we also include the dummy variable for breastfeeding, while dropping those variables that were not significant in estimation (II). By including breastfeeding, we reduce the sample size further and, more importantly, we drop all cases of neonatal mortality, i.e. when a child dies before completing one month of age. This is owing to the construction of the breastfeeding dummy to avoid a reverse causality bias. Even with these caveats, we find that insufficient breastfeeding has a strong effect on increasing postneonatal mortality and is highly statistically significant. Based on the estimated marginal effects, the risk of postneonatal mortality is 0.8 percentage points higher for children who have not or not fully been breastfed, as compared to children who have been breastfed for at least six months. This is all the more important as more than 30 per cent of all children in our sample are breastfed for less than the WTO recommended six months.

Among the other determinants, we find that a short preceding birth interval, mother's education, household size and premature delivery remain statistically significant, highlighting the particular robustness of these findings. The fact that the dummy for multiple delivery loses its significance is owing to the fact that most of those children who are part of a multiple delivery and who don't live to their first birthday die in fact within the first 30 days of their lives – and are therefore dropped from estimation (III).

6. Conclusion

Infant and under-five mortality in Jordan has decreased steadily over the last decades, reaching 21 and 24 per 1,000 live births in 2007, respectively. This ranks the country slightly better than the median of the 194 countries for which comparable data are available, and well above average for countries in the lower middle-income group. In spite of this progress, however, additional efforts will be required to achieve the Millennium Development Goal of reducing under-five mortality by two thirds by 2015, compared to its level in 1990, when it stood at 40 deaths per 1,000 life births. During the remaining eight years, a further reduction from 24 to 13 will thus be necessary to achieve the goal, posing an important development challenge.

The aim of this study was to assess the main determinants of infant and under-five mortality; however, as the latter is mostly driven by the outcomes of the former, we focus our analysis on infant mortality. We also discuss different estimation methodologies and argue that the logit estimation is most appropriate for our purpose.

Our results highlight certain areas where Jordan is already doing well, but they also point to a number of possible interventions that could help the country get closer to achieving MDG 4 on time. While econometric estimates must always be interpreted with caution – owing to problems with the underlying data, simplifications in the modelling of the relationships between variables, and the estimation procedure itself –, we are confident that our results can be a useful tool to inform the necessary policy discussions.

Most importantly, we find that at Jordan's current development stage, behavioural factors seem to matter more for infant and under-five mortality than traditional health and infrastructure interventions. This pattern reveals itself when it comes to birth spacing and breastfeeding, but also a mother's age at birth, education level, and smoking status.

Further, we find a disconcerting change over time in the effect of a child's sex on the risk of infant mortality. While the biological advantage of girls is reflected in our estimation results for the entire 35-year period before the survey, which show a significantly higher infant mortality risk for boys, this effect disappears during the 10-year and 5-year periods before the survey. Against the backdrop of overall improvements in health care and the reduction in infant mortality, we conclude that boys have benefited relatively more from such developments than girls. Insofar as this uneven development is owing to a cultural preference for boys, a renewed push for the protection of the rights of the girl child can be expected to yield further reductions in infant mortality.

While the number of very young mothers has already declined over the last decades (see footnote 13), presumably resulting in lower infant mortality rates, our results suggest that additional efforts to reduce smoking, increase birth spacing, and increase the duration of breastfeeding could make a significant contribution to further reduce infant mortality rates. Public awareness campaigns, such as those already put in place by the government against smoking, could be tailored to the specific target audience of smoking young women and mothers, and stepped up to include campaigns for family planning (in terms of birth spacing) and the benefits of breastfeeding. If applied in a sustained and well-targeted fashion with broad geographical and social outreach, such campaigns have the potential to be a cost effective and powerful tool in combating infant and under-five mortality.

Concerning education, our results suggest that additional efforts in increasing girls' and women's education levels – while contributing to the achievement of MDG 3 (promotion of gender equality) – would also create synergies with MDG 4, since a mother's education has a negative and statistically significant impact on infant mortality.

As could be expected based on the broad coverage and quality care provided by Jordan's health sector, determinants such as other public infrastructure, vaccine immunization status, and the choice between public and private health facilities do not seem to influence infant mortality. Large increases in government spending on traditional health services, in addition to current trends, would therefore be unlikely to present an efficient contribution to the required reduction in infant mortality.

As one exception to this general result, we find that additional government efforts in providing full coverage with access to safe drinking water could still contribute to the reduction of infant and under-five mortality rates. While MDG 7 only calls for a reduction by half of the proportion of people without sustainable access to safe drinking water, a more ambitious goal of full coverage seems achievable for Jordan, with the combined benefit of synergies in terms of reduced infant mortality.

In sum, our study suggests that Jordan needs to build on past achievements by stepping up efforts to further reduce infant and under-five mortality, in order to achieve MDG 4. The most efficient policy interventions are likely to be public awareness campaigns to target behavioural variables. One central behavioural component in this context is the promotion of gender equality, both in terms of improved health care for young girls and in terms of access to education. If in addition the percentage of smoking mothers can be effectively reduced, birth intervals increased and the average duration of breastfeeding expanded, Jordan may yet achieve the goal of reducing under-five mortality by two thirds on time by 2015. Increased public spending in these areas could thus be a more efficient tool for achieving the desired development outcomes.

References *[to be updated]*

Berg, Cynthia (1995): Prenatal Care in Developing Countries. The World Health Organization Technical Working Group on Antenatal Care. Journal of the American Medical Women's Association 50(5): 182-186.

Berry, William D., and Stanley Feldman (1985). Multiple Regression in Practice. Beverly Hills, CA.

Charmarbagwala, Rubiana, Martin Ranger, Hugh Waddington, and Howard Nial White (2004): The Determinants of Child Health and Nutrition: A Metaanalysis. IEG Working Paper. Washington, DC.

Cox, D. R. (1972): Regression models and life tables. Journal of the Royal Statistical Society. Series B (Methodological) 34(2): 187-220.

Deaton, Angus, and Salman Zaidi (1999): Guidelines for Constructing Consumption Aggregates for Welfare Analysis. Working Paper 217, Princeton University, Woodrow Wilson School of Public and International Affairs, Research Program in Development Studies. Princeton, NJ.

Department of Statistics [Jordan], and Macro International Inc. (2008): Jordan. Population and Family Health Survey 2007. Calverton, Maryland.

Filmer, Deon, and Lant H. Pritchett (2001): Estimating Wealth Effects without Expenditure Data – or Tears. An Application to Educational Enrollments in States of India. Demography 38(1): 115-132.

Fuse, Kana, and Edward M. Crenshaw (2006): Gender imbalance in infant mortality: A cross-national study of social structure and female infanticide. Social Science & Medicine 62 (2006): 360-374.

Jones, Andrew M. (2005): Applied Econometrics for Health Economists. A Practical Guide. 2nd edition, York, UK.

Lantz, Paula, Melissa Partin, and Alberto Palloni (1992): Using Retrospective Surveys for Estimating the effects of Breastfeeding and Childspacing on Infant and Child Mortality. Population Studies 46(1): 121-139.

Ministry of Health [Jordan] (2008): Annual Statistical Book. URL: http://www.moh.gov.jo/MOH/Files/Publication/report2008_1.pdf

Montgomery M., M. Gragnolati, K. Burke, E. Paredes (2000): Measuring Living Standards with Proxy Variables. Demography 37(2): 155-174.

Mosley W.H. and L.C. Chen (1984): An Analytical Framework for the Study of Child Survival in developing countries. Population and Development Review, Supplement to Vol. 10: 25-45.

Palloni, Alberto, and Sara Millman (1986): Effects of Inter-Birth Intervals and Breastfeeding on Infant and Early Childhood Mortality. Population Studies 40(2): 215-236.

Rutstein, Shea O. (2000): Factors associated with trends in infant and child mortality in developing countries during the 1990s. Bulletin of the World Health Organization 78(10): 1256-1270.

Rutstein, Shea O., and Kiersten Johnson (2004): The DHS Wealth Index. DHS Comparative Reports No. 6. Calverton, Maryland.

Titaley, Christiana, M. J. Dibley, K. Agho, C. L. Roberts, J. Hall (2008): Determinants of neonatal mortality in Indonesia. BMC Public Health 8:232.

Uddin, Jamal, and Zakir Hossain (2008): Predictors of Infant Mortality in a Developing Country. Asian Journal of Epidemiology 1(1):1-16.

UNDP (2008): Human Development Indices: A Statistical Update 2008. New York.

UNDP (2007): Human Development Report 2007/08: Fighting Climate Change. Human Solidarity in a Divided World. New York.

United Nations (2009): The Millennium Development Goals Report 2009. New York. URL: http://www.un.org/millenniumgoals/pdf/MDG%20Report%202009%20ENG.pdf

UNRWA (2009): Annual Report of the Department of Health, 2008.
URL: http://www.un.org/unrwa/publications/pdf/ar_health2008.pdf

UNSD (2009): Millennium Development Goals Indicators.
URL: http://mdgs.un.org/unsd/mdg/

Vos, Rob, Ruth Lucia, Mauricio León, José Rosero, and José Cuesta (2004): Health. In: World Bank, and Inter-American Development Bank (2004) Ecuador: Creating Fiscal Space for Poverty Reduction. A Fiscal Management and Public Expenditure Review, Volume II, Report No. 28911-EC. Washington D.C.

WHO (2006a): Health System Profile Jordan. WHO Regional Health Systems Observatory – EMRO.
URL: http://gis.emro.who.int/HealthSystemObservatory/PDF/Jordan/Full%20Profile.pdf

WHO (2006b): Report of a WHO Technical Consultation on Birth Spacing. Geneva, 13-15 June 2005.

WHO (2005): World Health Report 2005: Make every mother and child count. Geneva.

WHO (2003a): World Health Report 2003: Shaping the future. Geneva.

WHO (2003b): Global Strategy for Infant and Young Child Feeding. Geneva.

Woodridge, Jeffrey (2002): Econometric Analysis of cross section and panel data. Cambridge, MA.

World Bank (2009): World Development Indicators online. URL: ???

World Bank (1997): Jordan Health Sector Study. Washington, DC.

Need to add:

- Online source on Cox model and application in Stata
- IMF Independent Evaluation Office (2005)

Annex

Table A.1: List of Determinants of Infant and Child Mortality

Determinant	Expected effect on mortality	Type of variable	Number of observations[1]
Personal and biological characteristics			
Infant's/child's sex	Increased risk of infant mortality in boys	Dummy variable takes on the value 1 if the child is male and 0 if it is female.	41,297
Premature delivery (proxied by low birth weight)	Increased risk of infant and child mortality of premature/underweight newborns	Dummy variable takes on the value 1 if the child's weight at birth is below 2500 grams and 0 if it is above.	8,146
Multiple delivery	Increased risk of infant and child mortality of children that are born as part of a multiple delivery	Dummy variable takes on the value 1 if the child is part of a multiple delivery and 0 otherwise.	41,297
First born	Ambiguous effect	Dummy variable takes on the value 1 if the child is the first-born and 0 otherwise.	41,297
Birth order 4 and higher	Increased risk of infant and child mortality if birth order is 4 or higher	Dummy variable takes on the value 1 if the child is of birth order 4 or higher and 0 otherwise.	41,297
Preceding birth interval	Increased risk of infant and child mortality if the preceding birth interval is shorter	Dummy variable takes on the value 1 if the preceding birth interval is less than 33 months and 0 otherwise.	41,146
Behavioural characteristics			
Mother smokes tobacco	Increased risk of infant and child mortality if mother smokes	Dummy variable takes on the value 1 if the mother smokes tobacco (cigarettes and/or nargila) and 0 if she doesn't.	41,297
Use of private/public health care	Ambiguous	Dummy variable "private" takes on the value 1 if delivery takes place in a private facility and 0 otherwise.	8,261
Pre-natal controls	Increased risk of infant mortality if pre-natal controls are insufficient	Dummy variable takes on the value 1 if there were less than 4 pre-natal controls and 0 otherwise	4,591
Breastfeeding	Increased risk of infant and child mortality if breastfeeding is insufficient	Dummy variable takes on the value 0 if the child has been breastfed for at least 6 months, and if the child died before the age of 6 moths but has been breastfed up to its age at death (in full months). Otherwise, it takes on the value 1. All observations where a child dies at the age of less than one full month are dropped.	8,127
Household and community characteristics			
Safe drinking water	Increased risk of infant and child mortality if household lacks access to safe drinking water	Dummy variable takes on the value 1 if a household does not have access to an improved source of drinking water and 0 if it does.[2]	41,297
Improved sanitation	Increased risk of infant and child mortality if household lacks access to improved sanitation facilities	Dummy variable takes on the value 1 if a household does not have access to	41,297

		improved sanitation facilities and 0 if it does.[3]	
Socioeconomic status (wealth index)	Decreased risk of infant and child mortality in wealthier households	Continuous household wealth index as routinely provided in DHS data	41,297
Urban residence	Decreased risk of infant and child mortality in urban households	Dummy variable takes on the value 1 if the household is located in an urban area and 0 otherwise.	41,297
Badia	Increased risk of infant and child mortality in Badia areas	Dummy variable takes on the value 1 if the household is located in the Badia region and 0 otherwise.	41,297
Central Region	Decreased risk of infant and child mortality in central region (including the capital, Amman)	Dummy variable takes on the value 1 if the household is located in the central region and 0 otherwise.	41,297
Southern Region	Ambiguous	Dummy variable takes on the value 1 if the household is located in the southern region and 0 otherwise.	41,297
Household size	Ambiguous	Discrete variable: total number of household members.	41,297
Age of mother at birth under 20	Increased risk of infant and child mortality for mothers under 20 years of age at time of birth	Dummy variable takes on the value 1 if the mother is less than 20 years old at time of birth and 0 otherwise.	41,297
Age of mother at birth above 30	Increased risk of infant and child mortality for mothers over 30 years of age at time of birth	Dummy variable takes on the value 1 if the mother is more than 30 years old at time of birth and 0 otherwise.	41,297
Mother's education (years of formal schooling)	Decreased risk of infant and child mortality if mother has more years of formal schooling	Discrete variable: years of formal schooling of mother.	41,286
District immunization status	Decreased risk of infant and child mortality if immunization status is above average	Dummy variable takes on the value 1 if children in a district have higher vaccine coverage than the national average and 0 otherwise.[4]	41,297
Public health spending by governorate	Decreased risk of infant and child mortality if public spending per capita is higher than the national average	Discrete variable: ratio of public health spending per capita in governorate to national average health spending per capita	41,297
Access to water all day (proxy for "other infrastructure")	Decreased risk of infant and child mortality if household has access to water all day	Dummy variable takes on the value 1 if a household has access to water all day and 0 otherwise.	41,297
Year of birth dummy	Decreased risk of infant and child mortality if year of birth is more recent (i.e. closer to time of survey)	Dummy takes on the value 1 for all children born between 1971 and 1987, 2 for all children born between 1988 and 1997, and 3 for all children born between 1998 and 2007.	41,297

[1] Excluding children under one year of age and alive at the time of the survey.

[2] In line with the final report of the 2007 JPFHS (Department of Statistics and Macro International Inc., 2008), a household is considered to have access to an improved source of drinking water if its source of drinking water is specified as (i) piped into dwelling or yard/plot; (ii) rainwater; or (iii) bottled water.

[3] A household is considered to have access to improved sanitation if is has (i) a flush toilet; or (ii) a ventilated improved pit latrine. This differs from the definition in the final report of the 2007 JPFHS – which also includes pit latrines with slab as improved sanitation – but is in line with other literature on this topic (e.g. Rutstein and Johnson, 2004).

[4] In line with the final report of the 2007 JPFHS, we consider a child to be fully immunized if it has received at the age of 12 months, a set of eight vaccines (see footnote 5). Since no vaccine information is available for children who died under the age of one year, we use the available information for living children at the district level, and compare the mean immunization coverage at the district level to the mean immunization coverage at the national level.

Table A.2: Determinants of Under-Five Mortality in Jordan

	Parameter Estimates	Marginal Effects	Elasticities
Male	0.164***	0.0050	0.082
	(0.060)		
Multiple Delivery	1.734***	0.1193	0.038
	(0.108)		
First born	0.302***	0.0099	0.068
	(0.112)		
Birth order 4 and higher	0.153*	0.0047	0.059
	(0.080)		
Short preceding birth interval (< 33 months)	0.407***	0.0121	0.223
	(0.087)		
Mother smokes tobacco	0.384***	0.0135	0.039
	(0.084)		
Age of mother at birth under 20	0.533***	0.0196	0.066
	(0.091)		
Age of mother at birth above 30	0.247***	0.0080	0.052
	(0.083)		
Mother's education (years of formal schooling squared)	-0.002***	-0.0001	-0.225
	(0.001)		
Total number of household members	-0.139***	-0.0042	-1.062
	(0.015)		
Lack of access to improved source of drinking water	0.516***	0.0198	0.015
	(0.141)		
Lack of access to improved sanitation	-0.102	-0.0030	-0.021
	(0.075)		
Wealth index	-0.001***	0.0000	-0.017
	(0.000)		
Urban Residence	-0.012	-0.0004	-0.008
	(0.069)		
Badia Region	0.056	0.0017	0.008
	(0.087)		
Central Region	-0.269***	-0.0079	-0.093
	(0.077)		
Southern Region	0.040	0.0012	0.012
	(0.079)		
District has higher than average immunization status	-0.091	-0.0027	-0.035
	(0.070)		
Public health spending by governorate	0.270***	0.0082	0.274
	(0.085)		
Access to water all day	0.054	0.0016	0.047
	(0.094)		
Year of birth dummy	0.095*	0.0029	0.191
	(0.049)		
Sample size		33,105	
LR chi2(21)		480.96	
Prob > chi2		0.0000	
Pseudo R2		0.0463	

Note: All estimations use the largest possible sample, including children born between January 1971 and September 2007. We report parameter estimates, with standard errors given in parentheses, as well as marginal effects and elasticities. *** indicates significance at the 1 per cent level; ** at the 5 per cent level, and * at the 10 per cent level.