Determinants of under-5 mortality in Uganda: an econometric analysis

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1. Introduction

Infant and child mortality rates are among the most important indicators of child health, nutrition, implementation of key survival interventions, and the overall social and economic development of a population.

Economics include the study of child health and mortality for various more or less direct reasons: The health and productivity of adults is influenced by their health as children, and there may be an associated effect on the development of countries and economic growth. Children can therefore be considered economic actors in their own right and therefore of interest in economic analysis. When looking at development and developing economies, given the higher incidence of poor health in all age categories, child health and mortality would seem a relevant area of study towards a better understanding of economic and social conditions contributing to development. More generally, the health of children is a human right.

It has been well documented that poor health in childhood negatively affects future wages and labour force participation (Currie & Madrian 1998). The Millennium Development Goals were established by the United Nations in 2012 as "an international effort to reduce extreme poverty and hunger, fight disease, reduce child mortality and improve maternal health" by 2015 (UN 2014). While significant progress was made in the set timeframe, also on child health, a lot remains to be done and so the commitment was renewed under the Sustainable Development Goals (SDGs), focusing in particular on ending preventable deaths of newborns and children under five years of age.

An improved understanding of the determinants for child mortality reduction derived from economic analysis can guide the choice of interventions that are required to accelerate the pace of progress towards reduction of child mortality.

2. Research question

In this paper, using data from two Demographic and Health Surveys (referred to herewith as DHS) conducted in Uganda in 2006 and 2011, I investigate factors that have contributed to the decline in under-5 mortality in Uganda.

This paper addresses one research question: **What are the key determinants for reduction in child mortality in Uganda?**

Reducing under-5 mortality and meeting the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) by 2020 is a priority set by the government of Uganda and international development partners. I am contributing to an informed effective allocation of resources to those interventions that drive reductions in under-5 mortality in Uganda.

Hypothesis 1 linked to the research question is: Well-known and cost effective **public health measures have contributed to the decline in under-5 mortality in Uganda.**

I use a logistic regression model to identify key determinants for the reduction in under-5 mortality in Uganda, using DHS data from two surveys from 2006 and 2011. They include data on children born five years before the surveys were conducted, in 2001 and 2006. I then apply an Oaxaca-Blinder decomposition analysis to identify which of these determinants explain the largest part of the reduction. By identifying the key determinants in Uganda using these econometric models, it is my intention to contribute to a better understanding of the policies that could help further reduce under-5 mortality in Uganda and hopefully, with other associated research in other countries as well.

3. Limitations

As already stated, in this paper I seek to identify the determinants for reduction in under-5 mortality in Uganda. A limitation in the study is that the pooled DHS sample includes only individual recode for children born and dead or living five years when the survey was conducted and we consider only the decline in under-5 mortality on the basis of this sample.

I use a direct approach to calculating child deaths in the pooled sample: a true cohort life table approach. One limitation of this approach is that reliability of information on potential correlates declines when the time lag for observations increases.

I present the theoretical underpinnings to the importance of child mortality to economic growth in order to highlight the importance child mortality to economic development through its association with growth. A limitation is that I do not estimate the association of under-5 mortality rate with economic growth. It would be interesting for future research to test the association of under-5 mortality rates with growth in GDP per capita using cross-sectional national data.

4. Definitions

The terms child mortality and under-5 mortality are used intermittently in literature. The theoretical underpinnings to this paper concern the health of children, and economics theory and research use the term to include children from birth to and above the age of 5. I therefore in chapter six, use the term child mortality.

For the rest of the paper, I use the term under-5 mortality to maintain the connection with the data used for analysis, which includes children in the age range birth to age 5. The global priorities, including those of the MDGs, focus on under-5 mortality as a measure of child health.

Under-5 mortality is comprised of two essential age segments: infant and under-5. Infant mortality refers to deaths in the period up to 12 months of age and is comprised of neonatal and post-neonatal

mortality. Neonatal mortality refers to deaths taking place from birth up to 28 days of age. Post-neonatal mortality deaths are those that occur from age 28 days up to age 12 months. Neonatal and post-neonatal mortality rates for a cohort sum up to the infant mortality rate. Under-5 deaths are those that occur before the age of 59 months (World Health Organization 2005).

5. Organisation of the paper

The rest of the paper is organised as follows: Chapter six provides an overview of the theoretical underpinnings to the study of child mortality in economic research. In section 6.1, I present key models used in research, in section 6.2 I present some of the empirical research conducted on the topic and also include research on the association between child mortality and growth. I do this even though the focus of this paper is not growth, but given the importance placed on growth for the overall development of countries and for child mortality, it adds to the understanding of the role of child mortality in the field of economics. Several of the variables that in research are found to have an effect on under-5 mortality, are included in the analysis done for this paper (refer to chapters 8 and 9). Chapter seven provides an overview of the empirical research and previous literature on child mortality in economics (7.1). Section 7.2 includes an overview of some of the research conducted on the association between child mortality and growth, section 7.3 provides an overview of the particular country context of Uganda as and section 7.4 includes an overview of the international community's commitment to accelerate efforts to achieve a series of development goals - the Millennium and Sustainable Development Goals (MDGs/SDGs). Chapter eight presents the method and data used in the analysis done to respond to the research question. Chapter nine presents the results of the statistical analysis. Chapter ten concludes.

6. Theory – child mortality and economics

6.1   Why child mortality matters in economics

Economic models of child health and mortality
Child health is an important indicator of the state of development and progress in society. Also, health in childhood is an important predictor of health and productivity in life and in turn, the health of adults affects the health of their children. Economic theory includes different models for analyzing child mortality directly or indirectly. I describe some key models below.

Fertility models
Endogenous fertility models include the many factors that people are assumed to take into account when making choices related to fertility, particularly when and if to have children and how many children to have. In these models however, only the economic factors are included explicitly and a vector of household preferences is used to model other factors implicitly.

Becker (1960) states the following:

"For most parents, children are a source of psychic income or satisfaction, and, in the economist's terminology, children would be considered a consumption good. Children may sometimes provide money income and are then a production good as well. Moreover, neither the outlays on children nor the income yielded by them are fixed but vary in amount with the child's age, making children a durable consumption and production good." (Becker 1960, p. 210).

In general, according to economic theory, an increase in income will result in increased consumption of goods at a ratio determined by the elasticity of various goods. On the basis of this theory, when a household's wage is increased, parents could be expected to have more children and/or to invest more time and money in the quality or human capital of their children (through education for example). In the Becker fertility model the income elasticity is higher for quality than for quantity, and a household would correspondingly respond to an increase in income by increasing its expenditures on a child's human capital relatively more than increasing the number of children. On the issue of fertility, Becker concludes that (at least in developed countries where child mortality is now low) that

"…a decline in child mortality would induce a corresponding decline in births." (Becker 1960, p. 212).

In this model, an increase in household income will, through the elasticity mechanism, improve child health, reduce mortality and in most cases reduce fertility.

In adaptations of this fertility model, parents place value on children and make decisions about what to invest in them and how many to have, in different ways, and at different times – notably in the current generation and for future generations.

These adaptations contribute to optimal growth theory. One such model is the so called Barro-Becker model of endogenous fertility. The model assumes parents' choices regarding the size of their family are integrated with decisions about current and future consumption and intergenerational transfers, which includes an estimate of the current and future utility of children (Barro & Becker 1989). The model can be used to assess the effects of costs of child-rearing, tax levels, pension schemes and other social security measure on fertility levels, population growth and capital accumulation.

Boldrin and Jones (2002) follow the work of Barro & Becker by assuming households are utility-maximizing. In their variation of the economic model of endogenous fertility, parents factor in directly the potential of children contributing to their old age consumption. This model also includes infant mortality as an exogenous driving factor for fertility choices and the assumption is that when infant mortality decreases (or, survival rates increase), fertility decreases, since the costs of rearing the children increases. In countries where social security systems including pensions are not well developed, the model and its assumptions for income, earning, investments and savings motivations may be more relevant (Bardhan & Udry 1999). Empirical research in developing countries with higher mortality rates does not support the assumptions in the model since most countries with high mortality rates also have high fertility rates.

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Human capital model
Another way of analyzing child health is through a household production function approach. The human capital model as developed by Grossman (2000) treats health capital as a component of human capital, its value can be increased over time by investments (such as medical care and schooling) and it directly contributes to utility. The model can be used to estimate the so called production of health. The model predicts that child health will be influenced by the price of health inputs. The human capital model distinguishes between health and health inputs, and health care is treated as an input. In the model, parents care primarily about health.

Mosley and Chen (1984) developed a framework for studying child mortality which assumes that child health is a function of many different factors - biological as well as socio-economic - and households or parents seek to improve their children's chances of survival by maximizing the input of these variables.

Mosley and Chen state they the developed the framework:

> "to clarify our understanding of the many factors involved in the family's production of healthy children in order to provide a foundation for formulating health policies and structures" (Mosley & Chen 1984, p. 40).

They argue that fertility models did not adequately address the complicated nature of child mortality, since:

> "… a child's death is the ultimate consequence of a cumulative series of biological insults rather than the outcome of a single biological event.'' (Mosley & Chen 1984, p. 29)

Macassa, Hallquist and Lynch (2011) acknowledge the importance of Mosley and Chen's work, but also criticize it for failing to incorporate more indirect or macro factors affecting child health, such as national health, and health related government polices, institutions and macroeconomic variables, and over-emphasizing decision-making at the individual level.

Huynen, Martens and Hilderink developed a framework building on that of Mosley and Chen. The core concepts are similar to those of Mosley and Chen, but they include a macro-level category of determinants that are seen to provide a more complete picture of the many factors and mechanisms that affect health: so called "contextual determinants" (Huynen, Martens & Hilderink 2005, p. 2). The framework is used for more general population health but is also used to study child health in particular.

Child mortality and growth

The positive effect of health on economic growth is identified either in exogenous growth models during the transition to the steady state or in endogenous growth models. Given that the association between health and growth is considered significant, I present research conducted on the association between

child mortality and growth in chapter 7. However, since the focus of this paper is not on growth or the association with child mortality specifically, I do not provide an overview of the economic models used.

7. Empirical research on child mortality in economics

7.1   Empirical research on child mortality – an overview

Rajaratnam et al. (2010) analyse the levels of mortality using data time series data for 187 countries in order to document and understand progress against the MDG 4 which is the reduction in child mortality. The results point to accelerating declines in mortality, which is very encouraging. Other studies have demonstrated similar results when tracking changes in child survival following specific interventions such as malaria control or preventive activities, including Indoor Residual Spraying (IRS), LLIN coverage, Intermittent Preventive Treatment in Pregnancy and Infants (IPTp and IPTi), in a small and defined population and geographic area (Equatorial Guinea and The Gambia) (Kleinschmidt et al. 2009, Menon et al. 1990).

Recent reports from UN-IGME (2015) and Countdown reports (2015), report more current progress on the MDG targets and also suggest a positive correlation with investments in coverage of broader health interventions as well as improved wealth. Large differences remain between countries and between countries when grouped by income.

In one review of the improvements of health outcomes, Radelet (2010) group 17 countries in Africa in categories of progress suggesting the changes in economic growth and poverty reduction have been largely driven by changes in macroeconomics and governance. This is consistent with the theoretical framework defined by Mosley and Chen (1984) and Huynen, Martens and Hilderink (2005) that include proximate variables and globalization in the analysis of child mortality. Concurrent with positive changes in the macroeconomic environment, in the 1990s and 2000s governments and the international community have been implementing interventions focused on controlling HIV and malaria, and improved measures to diagnose, prevent and treat these illnesses have become available, notably Indoor Residual Spraying, Long-Lasting Insecticide Treated Nets (LLINs) and Artemisinin Combined Therapy (ACTs). In summary, changes are happening on several fronts that may contribute to the decline in child mortality.

I group the presentation of empirical evidence of child mortality in the key variables that have been found to be of particular importance to child mortality in economic research, and that also have a basis in the theoretical framework presented in the previous section: Income/wealth, education, maternal factors, access to health services including antenatal care and geographic factors.

Income/wealth
Income/wealth is a key household level socio-economic variable used in the Mosley and Chen framework. It operates through proximate determinants to influence mortality primarily by impacting

on the household's ability to source goods and services (Mosley & Chen 1984, p 36). Empirical evidence shows a significant negative association between child mortality and wealth. The association is found at both the macro and the micro level. Since this paper uses household data and focuses on household characteristics and health service delivery, I focus on research focused on the micro level.

Houweling and Kunst (2010) assume that the socio-economic situation of the household strongly influences the risk of a child dying. In their review of international evidence on child mortality in 55 low and middle income countries, they find that child mortality is significantly higher in the poorer and least educated compared to the richer wealth population segments. Ownership of assets is used as the measure of wealth. They find mortality rates differ between the wealth segments in all countries, richer and poorer, and also between the age segments in the same with mortality being higher among infants (less than 12 months) than children (12-59 months). Wealth impacts on the education of the mother, on the purchasing power and the ability to buy health services and wealthier households are likely to have better access to improved sanitation as well as education.

Education
It has been well documented that maternal education affects child health. Caldwell (1979) demonstrates the influence of a mother's education on the health of the child, based on a study in Nigeria, showing that education works through many different channels, which ultimately impacts on the health of her children. This is consistent with the theoretical framework of Mosley and Chen where the mother's education level works directly through proximate determinants, by influencing her choices for her own health and therefore the morbidity and mortality of her child (Mosley & Chen 1984, p. 34).

Houweling and Kunst (2010) show the association between household wealth and mother's education. But there has been much research to confirm the complex ways in which education impacts on the health of children and why education has additional direct effects on child mortality. One is that educated women are better able to make informed choices about their own health and prevention and treatment of illness. Hobcraft (1993) found when investigating data from 25 developing countries, that while children of uneducated mothers tended to suffer more illness, the main difference in mortality is related to the prevention and treatment of diseases. He found evidence that educated women were more likely to seek antenatal care, be vaccinated against tetanus during pregnancy, to give birth in the presence of skilled personnel and make sure that their children were fully vaccinated. He also found less evidence of stunting among children born to educated mothers, meaning children receive better nutrition.

Characteristics of the mother
A number of characteristics of the mother, in addition to the education level (as outlined above) are found to have significant effects on child health. This notion has a solid foundation in economic theory as well, both in the human capital and endogenous fertility models. Manda, in a 1999 study on determinants of child mortality in Malawi finds the mother's age at childbirth to have a significant positive effect on the infant chance of survival, and that the risk of infant mortality was higher for younger mothers. Under- and malnutrition is one of the largest direct causes of child deaths worldwide

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(World Health Organization 2009) and is related to breastfeeding, which provides both nutrition and protects children from diseases caused by poor sanitation, and is also related to the mother. Seeking (and accessing, see below) health services during pregnancy and delivery are additional important maternal determinants of child health.

Access to and quality of health services, and geographic factors
In endogenous fertility models, households make decisions about access to health care as part of the various decisions for investing in children (Becker 1960; Barro & Becker 1989). In the Mosley and Chen framework, access to health care is a socio-economic variable but also a proximate determinant as one component of personal illness control (Mosley & Chen 1984, p. 28). Access to and quality of health services play an important role in both prevention and treatment of illness. Because most maternal and child deaths occur during or shortly after delivery, antenatal care is found to be closely associated with the survival of both mother and child. So is the attendance of skilled personnel (World Health Organization, 2009). Empirical research points to the significance of health services to child health, including antenatal care[1].

In theory, geographic factors are associated with child mortality at different level. In the Huynen, Martens and Hilderink framework (2005, p. 3), geographic factors is one of four categories to directly impact on child mortality. Evidence from research shows a positive impact on child mortality from residing in an urban setting (Wang 2003). The reason is likely that factors found to be positively associated with child health, including those mentioned above, are more readily available in urban areas, particularly in developing countries. Feng et al. in a study on neonatal mortality (2011) shows large positive effects of delivering in hospital compared to delivering at home, and also increased chances of survival from hospital deliveries urban areas (and lower in rural).

7.2   Empirical research on child mortality and growth

There is ample research in economics that shows better health to have a positive impact on GDP per capita and economic growth. Sustained growth depends on levels of human capital which increases as a result of better education and better health.

Jeffrey Sachs (2001) made the case early for increased spending on health, because of its effect of growth and development, and he writes:

> "Improving the health and longevity of the poor is an end in itself, a fundamental goal of economic development. But it is also a means to achieving the other development goals relating to poverty reduction. The linkages of health to poverty reduction and to long-term economic growth are powerful, much stronger than is generally understood. The burden of disease in some

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[1] Antenatal care involves the screening for risk factors that may increase the possibility of specific adverse pregnancy outcomes as well as providing therapeutic interventions such as iron supplements and tetanus injections; and educating pregnant women on safe birth and potential emergencies. (World Health Organization, 2011b)

low-income regions, especially sub-Saharan Africa, stands as a stark barrier to economic growth and therefore must be addressed frontally and centrally in any comprehensive development strategy." (Sachs, 2001, p. 1)

Subramanian and Corsi (2014) in a study using 99 DHS surveys from 36 countries, investigate factors that have contributed to the declines in under-5 mortality rates in Sub-Saharan Africa, focusing specifically on country level growth and changes in coverage of maternal and child health interventions. The association has a theoretical foundation both in the frameworks by Macassa, Hallquist and Lynch (2011) and Huynen, Martens and Hilderink (2005) that incorporate macro-economic and indirect factors into the analysis of child mortality. Subramanian and Corsi (2014) find a consistent association between changes in coverage of maternal and child health interventions and reduction in under-5 mortality rates, but that the association with economic growth is inconsistent in the poorest countries where child mortality is still high.

Rivera and Currais (1999) in a study of health care expenditures in OECD member states between 1960 and 1990, show that countries with higher health expenditures also experience higher levels of economic growth. They use health care expenditures as a proxy for health in the population.

Lopez, Rivera and Currais (2005) also find that good health indicators was positively associated with reduced poverty levels and suggest this is because better health enables individuals to allocate more to investment in human capital as well as savings. It also contributes to improved productivity of the labour force.

Barro (1997), using panel data from 100 countries, finds that improved health is positively associated with economic growth and that the growth rate is enhanced by education levels, lower fertility, improved levels of governance and lower inflation.

Bloom et al. (2004) use a production function model and analyse the impact of health on economic growth through its effect on labour productivity. They use panel data from countries observed at 10 years intervals between 1960 and 1990. They find a strong correlation between health and economic growth, and that: "good health has a positive, sizeable, statistically significant effect on aggregate output" (Bloom et al. 2004, p. 11).

Weil (2014) argues that income and health are strongly correlated, but suggests that the direction of causality is not sufficiently clear; that while improvements in health outcomes may have a positive effect on growth, there is an identification problem in most analyses of growth. Analyses made with better identification instead or shorter time periods tend to find small (sometimes negative) and delayed effects of health on economic growth. He argues that models should take into account more factors and also analyse change over longer time periods.

7.3   Child mortality and growth in Uganda

Uganda's under-5 mortality rate has fallen from 187 deaths per 1,000 live births in 1990 to 148 in 2000 to 55 in 2015 (Countdown, 2015). Uganda has achieved its MDG goal for child mortality (62 deaths per 1,000 live births). While this is very encouraging, they have ways to go to achieve the SDG goal of reducing under-5 mortality to at least as low as 25 deaths per 1,000 live births (UN-IGME, 2015).

In this paper we use Demographic Health Surveys (DHS) from 2006 and 2011 to analyse drivers and do not consider the national overall under-5 mortality rate. In our pooled sample (see chapter 8) we observed a 2.7% decline in under-5 mortality between the two time periods. The rate of decline would need to increase if the SDG goal of 25 (from the 2015 number of 55) or fewer deaths per 1,000 live births is to be achieved.

From data and analysis made available by the World Bank (2016), after many years of conflict, Uganda experienced a sustained period of macroeconomic stability, post-conflict rebound, and investment response and high growth during 1987-2010. Real gross domestic product (GDP) growth averaged 7% per year in the 1990s and the 2000s, placing Uganda among the 15 fastest growing economies in the World.

However, over the past decade, the country witnessed more economic volatility. The World Bank forecasts that Ugandan economy will grow at a rate of approximately 5.9% in FY16/17, increasing to 6.8% in FY17/18, and thereafter stay on an upward trajectory at least if major infrastructure projects are implemented as planned and private investment, particularly in the oil sector increases. (World Bank 2016).

7.4   The Millennium Development Goals: Progress and challenges

One of the Millennium Development Goal– the MDG 4 target - agreed to in 2000 by world leaders calls for reducing the under-five mortality rate by two thirds between 1990 and 2015.

The commitment was renewed in 2012, aiming for a continued post-2015 focus to end preventable child deaths. A new framework – the Sustainable Development Goals (SDGs) was agreed: "by 2030, end preventable deaths of newborns and children under five years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 deaths per 1,000 live births and under-five mortality to at least as low as 25 deaths per 1,000 live births by 2030" (UN-IGME 2015, p. 2).

UN-IGME updates child mortality estimates annually. Substantial declines in infant and under-5 mortality have taken place. Since 1990, the global under-five mortality rate has dropped by 53 percent, from 91 deaths per 1,000 live births in 1990 to 43 in 2015, and the annual number of under-five deaths dropped from 12.7 million to 5.9 million. In sub-Saharan Africa, the region with the highest under-five mortality rate in the world, under-five mortality reduced by 4.1 percent annually in 2000–2015.

Between 1990 and 2015, 62 of the 195 countries with available data achieved the MDG 4 target of a two-thirds reduction in the under-five mortality rate between 1990 and 2015 (UN-IGME 2015).

The remarkable decline in under-five mortality since 2000 has saved the lives of 48 million children under age five. Despite these gains, progress remains insufficient to reach MDG 4 globally and in many regions, particularly in Caucasus and Central Asia, Oceania, Southern Asia and sub-Saharan Africa.

Progress in reducing neonatal mortality rate is slower than for the post-neonatal under-five mortality rate in the majority of countries. The share of neonatal deaths is projected to increase, from 45 percent of under-five deaths in 2015 to 52 percent in 2030. Moreover, 63 countries need to accelerate progress to reach the SDG target of a neonatal mortality rate of 12 deaths per 1,000 live births by 2030 – more than the 47 countries for the under-five mortality target (UN-IGME 2015).

If the Sustainable Development Goal (SDG) target on child survival is to be achieved, particularly in 47 high mortality countries in sub-Saharan Africa, the pace of reduction needs to increase. To achieve the SDG target of an under-five mortality rate of 25 or fewer deaths per 1,000 live births by 2030, 30 countries must at least double their current rate of reduction and 11 of those 30 countries must at least triple their current rate of reduction (UN-IGME, 2015).

8. Methods and Data

This paper was inspired by an article by Demombynes and Trommlerová from 2012, analyzing drivers for infant mortality in Kenya which gave important insights in how to use DHS statistics and the Oaxaca-Blinder decomposition analysis. The UN-IGME 2015 report presents the most recent information available on progress against the MDGs and post-MDG (SDG) priorities which together with the 2010 paper by Radelet guided the selection of key variables in this paper. Fortin, Lemiux and Sirpo (2010) informed the application of the Oaxaca-Blinder decomposition analysis and why it can be a useful method to analyse a public health issue such as under-5 mortality, and its possible other uses. In addition, the choice of statistical model was informed by Agresti's 2007 publication on categorical data analysis.

8.1   Data

Data sets
There are different methods to calculating child mortality, direct as well as indirect methods. Direct methods use data on date of birth, survival status and dates of death of children. There are three methods, described in some detail by Rutstein and Rojas (2006):
- A vital statistics approach in which the number of deaths of children under age 5 years in a particular period are divided by the number of births in that period.
- A true cohort life table approach in which deaths to children under age 5 years of a specific cohort of births are divided by the number of births in that cohort

- A synthetic cohort life table approach in which mortality probabilities for small age segments based on real cohort mortality experience are combined into the more common age segments.

Because indirect methods require much stronger assumptions than is possible for the expanded analysis on under-5 mortality (given the time lag between birth and death at the point of data collection analysis in 2006 and 2011 respectively), I opt to use direct methods (Demombynes & Trommlerová 2012). To compensate for the time lag, I analyse the individual and household-level correlates of under-5 mortality and work with actual survival data of individuals rather than aggregate figures. This corresponds to the true cohort life table approach mentioned above.

DHS surveys collect information from women aged 15-49 years on their full birth histories, children's health status, and household characteristics, among other things. Detailed sampling procedures used in the collection of DHS data have been reported elsewhere (Rutstein & Rojas 2006). The primary focus of this paper is under-5 mortality. Specifically observations on children born alive five years before the respective survey are used. Given the precise dates of the DHS interviews, the child survival data used is based on a set of births that occurred in 2001 and 2006.

Expanding the analysis to under-5 mortality, and not considering infants required this paper to correlate each of the basic characteristics, since each birth would have taken place in circumstances removed in terms of time from the characteristics of the household.

The pooled sample consisted of 16,247 observations - 7878 observations from the 2006 and 8369 observations from the 2011 DHS respectively.

Outcome and predictor variables
The main outcome variable is under-5 mortality (death between birth and 59 months). From the data set, this is measured at individual level by a binary variable which takes a value zero if the child died before the age of five and value 1 if the child is still alive. I selected predictor variables that are known to be important contributors to child health and mortality, many of which are included in the theoretical frameworks for the study of child mortality in economics, outlined in chapter 6, and also found in empirical research as seen in chapter 7. They include mother related characteristics such as education level and access to antenatal care (a key part of health services) as well as household level characteristics such as LLIN (see rationale below), wealth status, urban or rural location of residence, and access to drinking water and sanitation. These are explained briefly below:

Access to drinking water and sanitation: Information on the source of drinking water was represented by binary variables representing two stages of quality: one for surface water and zero for an improved water source. Surface water is a water source that is natural, can be ground water and has not been improved. Sanitation was represented by binary variables taking value one for improved sanitation and zero for no sanitation.

LLIN ownership: LLINs are included because of the global burden of malaria, and the proven cost-effectiveness of LLINs for the prevention of malaria[2]. Due to data unavailability on LLIN use for deceased children, we use a dummy variable on LLIN ownership by the household at the time of the interview as a proxy of protection offered by LLIN for the child.

Antenatal care including: Place of birth - a child is categorized as being born in a facility if it was born in a public or private health facility; Tetanus protection - protection against neonatal tetanus is achieved if a pregnant woman received at least one shot of tetanus vaccine during her pregnancy; Antenatal antimalarial – took any type of preventive antimalarial drug during pregnancy. The distinction between preventive antimalarial and treatment is important, since treatment would indicate malaria in pregnancy and this has been shown to significantly increase risk of low birth weight and infant mortality.

Rural/urban location of household residence: if the household resides in a rural or urban setting. Generally, and as stated in chapter 7.1, evidence from research shows a positive impact on child mortality from residing in an urban setting which is likely due to the fact that factors found to be positively associated with child health are more readily available in urban settings in developing countries.

Wealth: Households are categorized by wealth status, separated into quintiles, using the Demographic and Health Survey (DHS) Wealth Index which is an asset index that is used in all DHS surveys. It uses household ownership of assets and not income and expenditures. The quintiles are constructed with a principal components analysis of many different kinds of household assets. The continuous first principal component is broken into five intervals or quintiles, to give equal numbers of cases in each interval. The wealth quintiles are in one way a synthetic construct, because the values vary somewhat between surveys, but they still describe wealth well and are generally considered useful descriptors for tracking changes over time in say the infant mortality of children born to mothers in the bottom quintile, or the top quintile in 2006 and 2011. We use the DHS wealth index even though it is specific to each survey because it is the most reliable measure on hand to compare two surveys and over time, as indicated in a report by Rutstein and Staveteig: "While it is possible to calculate comparable wealth indexes by using the same set of variables and categories in every survey—as well as a standard set of z-scores and principal components analysis coefficients and standard quintile break points—differences between surveys in the questions asked and the ways in which questions are categorized make this procedure difficult to implement without discarding much of the information used in each country to construct the wealth index" (Rutstein & Staveteig 2014, p.4). New measures, such as the Harmonized Wealth Index (Staveteig & Mallick, 2014 p. 41) or the Comparative Wealth Index (Rutstein & Staveteig 2014, p. 37) might be the way forward for intertemporal analysis within a country, but some validation work remains to increase the comparability, especially on the harmonization of assets. It is therefore beyond the scope of this study, and we rely on the existing DHS Wealth Index.

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[2] See chapter 10 on policy recommendations for more on the relevance of LLINs for child mortality reduction.

8.2   Data analysis

The statistical analysis proceeded in two levels. First a descriptive analysis was computed in percentages and frequencies for predictor[3] variables to examine the sample distribution by the selected socio-demographic basic characteristics. Additional mortality estimates were disaggregated by the different levels of the predictor and was computed to gain initial insights about potential mortality determinants.

Secondly, I used a statistical regression model to identify significant determinants of mortality. Regression models are used to study the relationship between a dependent (outcome) and independent (predictor) variable(s). Many types of regression models exist in literature and the choice depends on the distribution of the outcome variable. I opted to use a logistic regression model, described by Agresti (2007) because the outcome variable is binary which renders a linear regression model (which is otherwise the most commonly used model) unsuitable. When the outcome variable is continuous however, a linear regression model is suitable as it works under specific assumptions of linearity, normality, equal variance among others.

Generally, the logistic regression model is used to test and describe the relationship between a binary outcome variable and one or more qualitative or continuous predictor variables. In this model, the conditional probability of observing a success (that is a child being alive in this case) is modeled as a function of selected predictor variable(s).

Denoting Y_i as the outcome indicator for child i (taking on value 1 if the child is alive and value of 0 if the child has died), the logistic regression model used in the analysis was fitted using the equation below:

$$\text{logit}\big(P(Y_i = 1)\big) = \beta_0 + \beta_i X_1 + \cdots + \beta_p X_p$$

Where:
- $logit\big(P(Y_i = 1)\big)$ is the log odds of the child i being alive
- X_i is the predictor i ($i = 1, \ldots\ldots\ldots\ldots\ldots p$: p being the number of predictors used)
- β_i is the effect of predictor i on the outcome variable. Since only categorical predictors are used, this gives the difference in the log odds of being alive (survival) between the current and reference category keeping other factors constant.
- β_0 is the log odds of child being alive for a child in the reference group under each of the categorical predictors

8.3   Building the model

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[3] In statistics also called categorical variables.

Cross-sectional surveys such as the DHS surveys, gather data on range of indicators which offer a multitude of predictor variables that can be included in a statistical model. There are a number of different approaches to selecting variables and fitting the model. The models should be complex enough to fit all the data while retaining focus on the research question at hand. (Agresti 2007).

To build the model for the analysis of my research question, I started with a set of univariate models where the outcome is regressed with each of the predictor variables independently to identify candidate predictors which would then be included in a multivariate model. From the univariate analysis, all predictors that have a p-value < 0.25 were selected for the multivariate model (Hosmer & Lemeshow 2000).

A backward elimination method, described by Agresti (2007) was used to identify the independent variables that are significantly associated with the outcome, and these were used to build the multivariate model. The backward elimination consists of removing predictors whose coefficient has the largest non-significant p-value (i.e the p-value associated with the test that the coefficient equals zero) one at a time from a complex/global model. The multivariate model facilitates studying of the association between the outcome and a selected predictor variable while adjusting for other predictor variables present in the model.

Multivariate regression is prone to collinearity, a situation where predictor variables are linearly related with each other which skew the model's standard errors. In other words, a variable may seem to have little effect on the outcome because it overlaps considerably with other predictors in the model, itself being predicted by other predictors. The backward elimination method is a way to deleting these redundant predictors, and helps to reduce standard errors of other estimated effects (Agresti 2007). In this analysis collinearity was assessed among the predictors using various inflation factors.

The analysis was conducted using the software Stata (version 12)[4]. Sample bias can generate misleadingly low p-values, and to accommodate the sampling design of the DHS survey, I included survey design settings for weighting and clustering[5], specifically by using the svy: stata routine to weight the sample. Based on the new p-values I would be able to see if variables could be excluded from the analysis and determine what effect that has on the explained part of the decomposition analysis (we explain this further and present the results below in section 9.3). P-values less than 0.05 (or 5%) were taken to be statistically significant.

8.4   The Oaxaca-Blinder decomposition analysis – background and its application

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[4] StataCorp, College Station, Texas, USA
[5] Survey settings were obtained from the DHS Guide to Statistics (2006) by Rutstein and Rojas,

Decomposition analysis is used to analyse what the key factors are behind for example growth in GDP. The Oaxaca-Blinder analysis allows for an analysis which simultaneously considers several possible drivers of the change observed over time and it breaks down the difference in a distributional statistic between two groups, or its change over time, into various explanatory factors. The approach provides a statistical decomposition of changes in the mean of a variable. It was introduced by Oaxaca (1973) and Blinder (1973) and was originally used in labour economics but has since been developed and applied to other areas of economics.

An important development to the decomposition analysis from its original form has been to extend them to distributional parameters other than the mean, to measure the difference in the variance.

Fortin et al. (2010) note that the goal of decomposition methods are often quite ambitious, such as attempting to analyse key factors behind growth or public health applications such as the study on child mortality. Strong assumptions should therefore ideally underlie the analysis. Decomposition methods do not necessarily provide information on the mechanisms underlying the relationship between factors and outcomes. However, when I have clarified which factors are quantitatively important and which are not – "what we want to estimate, and what assumptions are required to interpret these estimates as sample counterparts of parameters of interest) and then introduce estimation procedures to recover the object we want to identify" (Fortin 2010 p. 11) – decomposition analysis can be useful in isolating these factors into categories that can be explained and those that cannot.

An additional interesting benefit to decomposition analysis is that it can provide some "bottom line numbers" (Fortin 2010 p. 2) indicating the importance of particular factors, meaning that while studies show large statistically significant positive effects on under-5 mortality from the ownership of LLINs (Yukich et al. 2007) decompositions indicate that only a portion of under-5 mortality can be directly accounted for by for example LLIN ownership.

When I apply it to determining under-5 mortality, I first identify key variables that are known to generally contribute to under-5 mortality[6] and then describe the difference in the average number of child deaths per 1000 live births between one date and another (2006 and 2011 in this paper) as a function of the means of explanatory variables and estimated coefficients.

The Oaxaca-Blinder decomposition separates the change into an explained and a unexplained portion. I opted to include this level of analysis with the intention to provide a more robust measure of the possible drivers that emerge from a multivariate framework as it measures what proportion in the dependent variable can be explained by the factors identified through correlation.

9. RESULTS

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[6] See section 8.1 describing the predictor and outcome variables

9.1   Descriptive statistics

The pooled sample consists of 16,247 children under the age of five. 84% of these were from rural households and most of the children (60.7%) were born to mothers whose highest education level was primary school with only 3.2% born to mothers who achieved tertiary education. 57.1% of children resided in a household that owned at least one LLIN. It is noteworthy that LLIN ownership increased sharply from 2006 (35.6%) to 2011 (80.1%), which could mean that protection from malaria was more available to children in the second survey[7]. 70.6% of the children had access to an improved source of drinking water and only 29.3% only access to surface water. It is an interesting observation, since drinking water is correlated with diarrheal diseases which are a key contributor to child mortality. The distribution of children with access to improved sanitation is the reverse however, with only 23.8% of the sample having access to improved sanitation facilities. I have not been able to find a reason for this in the DHS surveys. The sample is distributed fairly evenly across the wealth quintiles with 25.7% in the poorest (1st) quintile and 18.6% in the wealthiest (5th). A similar distribution is seen for two of the sub-predictor variables to antenatal care: if the child was born in a facility (49.5%) or not (50.5%), and if the mother took an antimalarial preventive drug in pregnancy (52.1%) or not (47.9%). There is a larger difference in the distribution for the two other antenatal care sub-predictor variables, with 80.4% of the mother having received a tetanus injection in pregnancy and 71.3% iron supplement.

Table 1 summarises the distribution of children (observations) in terms of frequencies and percentages for the basic characteristics or predictor variables.

Table 1: Distribution of children across the selected socio-demographic basic characteristics

Predictor variable	2006		2011		Overall - total pooled sample	
	Frequency (N)	%	Frequency (N)	%	Frequency (N)	%
Access to drinking water						
Improved water source	5,465	67.8	5,687	73.6	11,152	70.6
Surface water	2,596	32.2	2,037	26.4	4,633	29.3
Access to sanitation						
Improved sanitation	1,624	20.1	2,137	27.7	3,761	23.8
No sanitation	6,436	79.8	5,582	72.3	12,018	76.2
Mother's education						
No education	2,034	24.3	1,427	18.1	3,461	21.3
Primary education	5,181	61.9	4,687	59.5	9,868	60.7
Secondary education	959	11.4	1,445	18.3	2,404	14.8

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[7] I return to the issue of LLIN ownership and its possible important correlation with a reduction in under-5 mortality in the concluding chapter.

Tertiary education	195	2.3	319	4.1	514	3.2
Household's wealth status						
1st wealth quintile (poorest)	2,139	25.6	2,030	25.8	4,169	25.7
2nd wealth quintile	1,820	21.7	1,550	19.7	3,370	20.7
3rd wealth quintile	1,555	18.6	1,405	17.8	2,960	18.2
4th wealth quintile	1,491	17.8	1,230	15.6	2,721	16.7
5th wealth quintile (richest)	1,364	16.3	1,663	21.1	3,027	18.6
LLIN ownership						
LLIN ownership	5,388	35.6	6,307	80.1	9,288	57.1
No LLIN ownership	2,981	64.4	1,571	19.9	6,959	42.8
Rural/urban area						
Urban	917	10.9	1,682	21.3	2,599	16
Rural	7,452	89	6,196	78.6	13,648	84
Antenatal care						
Born in a facility	3,438	41.1	4,600	58.5	8,038	49.5
Not born in a facility	4,919	58.9	3,269	41.5	8,188	50.5
Antenatal antimalarial drugs	2,772	55.9	2,342	48.2	5,114	52.1
No antenatal antimalarial drugs	2,188	44.1	2,513	51.8	4,701	47.9
Tetanus protection	3,861	77.4	4,073	83.5	7,934	80.4
No tetanus protection	1,128	22.6	803	16.5	1,931	19.6
Antenatal iron supplement	3,233	64.8	3,795	77.3	7028	71.3
No antenatal iron supplement	1,753	35.2	1,086	22.1	2839	28.7

9.2   Under-5 mortality by basic characteristics

Estimates of mortality disaggregated by basic characteristics are presented in Table 2. I present the estimates the pooled sample and then for each of the two DHS (2006 and 2011).

Mortality is the dependent variable and as can be seen in the column depicting the pooled sample, mortality was slightly higher in children from households without an LLIN (9.3%) as compared to those from households owning an LLIN (6.8%). For clarification, another way of saying this is that out of the total pooled sample, 9.3% of children living in households with no LLIN died before the age of five. Furthermore, rural children were associated with higher mortality (8.1%) compared to children residing in urban locations (6.6%), which is consistent with findings indicating the importance of geographical factors to child health and mortality (see section 7.1). Children from the wealthiest families (5th quintile) were associated with lower mortality (6%) compared to those in poorest category (9%). Higher mortality was observed in children of mothers with no education (8.9%) compared to those who had achieved

secondary (6.2%) and those of tertiary education (4.3%) which is supported by theory (see chapter 6) that the household's wealth status and the mother's education is associated with lower mortality.

The columns with estimates of mortality for 2006 and 2011 respectively, show some interesting results with regards to changes between the two points in time in the key variables and their impact on mortality. The association for mortality has reduced for all of the independent variables from 2006 to 2011. It is interesting to note that the mortality estimates for independent variables such as mother's education and wealth quintiles – correspond with findings in theory: when looking at the difference over time, there is lower mortality among children born to mothers with some education, and in the wealthier segments, and also in households with an LLIN. So, for example - in 2006 10.3% of children in the sample born to mothers with no education died before the age of 5, and in 2011, 6.8% died. The difference between 2006 and 2011 is smaller for LLIN ownership – 7.9% to 7.6%, which is interesting given LLINs are shown in the analysis that follows, to be statistically significant, and in the decomposition analysis contributes mostly to the explained part.

The reason cannot be seen here, but a possible explanation is that other variables, such as access to health care and/or macro-level factors have improved between the two time points contributing to a general reduction in mortality.

Table 2: Mortality by basic characteristic

	2006		2011		Overall - total pooled sample	
Predictor variable	**Frequency (N)**	**%**	**Frequency (N)**	**%**	**Frequency (N)**	**%**
Access to drinking water						
Improved water source	485	8.4	373	6.5	858	7.4
Surface water	250	9.8	143	7.2	393	8.6
Access to sanitation						
Improved sanitation	151	9.2	124	5.5	275	7.1
No sanitation	584	8.8	392	7.2	976	8
Mother's education						
No education	210	10.3	99	6.8	309	8.9
Primary education	494	9	325	7.1	819	8.1
Secondary education	63	7.2	85	5.5	148	6.2
Tertiary education	9	5.3	14	3.6	23	4.3
Household wealth status						
1st wealth quintile (poorest)	233	10.1	140	7.7	373	8.9
2nd wealth quintile	174	9.4	119	7.6	293	8.5
3rd wealth quintile	132	8	95	6.5	227	7.5

4th wealth quintile	136	9.2	78	6.6	214	8
5th wealth quintile (richest)	101	7.5	91	4.6	192	5.9
LLIN ownership						
LLIN ownership	252	7.9	403	6.3	655	6.8
No LLIN ownership	524	9.6	120	8.3	644	9.3
Rural/urban location						
Urban	70	8.4	99	5.1	169	6.6
Rural	706	9.1	424	6.9	1130	8.1
Antenatal care						
Born in a facility	283	8	296	6.3	579	7
Not born in a facility	485	9.6	255	7.1	710	8.6
Antenatal antimalarial drugs	105	4.8	213	4.4	318	4.5
No antenatal antimalarial drugs	175	6.5	16	5.5	191	6.4
Tetanus protection	206	5.5	195	4.6	401	5
No tetanus protection	75	6.6	36	3.9	111	5.4
Antenatal iron supplement	170	5.3	172	4.2	342	4.7
No antenatal iron supplement	111	6.3	57	5.1	168	5.8

9.3 Results of the fitted logistic regression models

To identify the determinants of mortality, the logistic regression model was fitted on the pooled sample. To fit the model, I employed a systematic process that proceeded with univariate models before fitting the final multivariable model. From the fitted univariate regression models, all predictor variables had a p-value > 0.25 except antenatal antimalarial drugs and antenatal iron supplement. These two variables were thus not used in the next analysis – multivariable model. This is interesting to note, given the distribution of the basic characteristics for the sample, presented in the descriptive statistics section and table 1. An explanation may be that given the time lag of the observations, and the more indirect effects from tetanus injection and iron supplements, they are not indicated as statistically significant in this model.

The rest of the variables were then entered into a global multivariable model and a backward elimination method was employed to select factors of significant effect. At each stage, the variable associated with the highest non-significant p-value was dropped. In table 3 the results of the model building process up to the final model are presented.

The final model indicated three factors that were statistically significantly associated with under-5 mortality: LLIN ownership, wealth status and mother's education. The odds of being alive were 1.2 times significantly higher in households that owned an LLIN compared to those that did not own one holding other factors constant. Similarly, in children living in the wealthiest (5th quintile) segment the odds of

being alive was 1.5 times significantly higher compared to those in the poorest (1st quintile) family category holding other factors constant. In addition when holding other factors constant, the odds of being alive was 1.7 higher for children born to mothers who had completed tertiary education, compared to those born to mothers with no education. This analysis did not find statistically significant effects of location of residence (rural/urban) and main source of drinking water used in the household on under-5 mortality and we therefore dropped these variables from the model.

Table 3: Results of fitted logistics regression models

Independent variable	Model				
	1	**2**	**3**	**4**	**5**
2011 DHS	1.25*	1.22*	1.21*	1.20*	1.20*
LLIN ownership	1.20*	1.20*	1.19*	1.19*	1.20*
2nd wealth quintile	1.04	1.02	1.02	1.02	1.02
3rd wealth quintile	1.19	1.19	1.20	1.21	1.21
4th wealth quintile	1.08	1.10	1.11	1.09	1.10
5th wealth quintile	1.30*	1.37*	1.36*	1.35*	1.41*
Surface water				0.91	0.91
No sanitation		1.11	1.12	1.12	1.12
Primary education	1.03	1.05	1.04	1.03	1.03
Secondary education	1.20	1.20	1.18	1.17	1.17
Tertiary education	1.66*	2.06*	2.04*	1.98*	1.98*
Not born in a facility				0.95	0.94
Rural location					1.11
Intercept (Constant)	9.31*	8.36*	8.25*	8.18*	7.48*

An asterisk (*) indicates significance (p-values) at 5%

9.4   Results of the decomposition analysis

Using the Oaxaca-Blinder decomposition, I separate the change into an "explained" and an "unexplained" portion – measuring the changes in the explanatory variables between the 2006 and 2011 DHS. Table 4 presents the results.

In this final part of the analysis, I assessed the contribution of the different factors to the observed decline in under-5 mortality between 2006 and 2011 using the Oaxaca-Blinder decomposition. I analyse the changes in the dependent variable – the probability of being alive – measured per 1000 live births. This decomposition measures what proportion in the dependent variable – here under-5 mortality - can

be explained by the factors identified in section 9.3: LLIN ownership, household wealth status, mother's education level and sanitation.

These independent variables are the same as in model 1 and 2 presented in Table 3. I test the proportion of the differences in mortality explained by each of these independent variables. To arrive at the results, I remove variables that are not statistically significant from the model step by step (refer to table 3). Therefore, variables where at least one level (say 5th wealth quintile) is shown to be statically significant (indicated by *) are kept and used in the decomposition analysis presented in Table 4. We do not remove sub-levels of a variable (1st wealth quintile for example) but treat as one variable. The main difference between the two models presented in Table 4, is that sanitation is removed from model 1.

The decomposition results are presented in Table 4. When I included only three variables (model 1), the explained part is only 19.7%. When I included one more variable – sanitation – the explained part increases to 22.6%. Testing for more variables, the explained part did not increase further indicating these are the four variables that contribute most to the explained part.

The results suggest that 22.6% of the observed decline in under-5 mortality can be explained statistically by the four factors of LLIN ownership, wealth status, mother's education level and sanitation. Most importantly, the increase in ownership of LLINs individually explained 17% of the observed decline (i.e 0.004 divided by 0.024). Changes in the remaining variables do not explain the decline in mortality to a significant degree. From this analysis, I conclude that LLIN ownership is the main contributing factor and the key determinant for the observed decline in mortality, out of the predictor variables included in the model.

Table 4: Results of the Oaxaca Blinder analysis

	Model	
	(1)	(2)
2006 survey	0.934	0.933
2011 survey	0.907	0.909
Difference between 2006 and 2011	0.026	0.024
Explained part	0.005(19.7%)	0.005 (22.6%)
Unexplained part	0.021 (80.3%)	0.019(77.3%)
LLIN ownership	0.004	0.004
Wealth quintile	0.001	0.001
Education	0.000	0.000
Sanitation		-0.000
Overall number of children	16,247	16,247
Number of children in 2006	7,878	7,878
Number of children in 2011	8,369	8,369

10.   Conclusions and policy recommendations

Under-5 mortality rates are among the most important indicators of child health, nutrition, implementation of survival interventions, and the overall social and economic development of a population and country. There is strong evidence from research to suggest that under-5 mortality has significant effects on the overall development of country. I have provided an overview of the theory underpinning research on under-5 mortality, including on the association between child health, mortality and growth. The evidence suggests a clear policy recommendation to increase coverage of interventions to promote child health, particularly in developing countries. It is recognized that health is multi-dimensional, contextual and difficult to measure there is a role for more research on the specific determinants for under-5 mortality and its reduction, to inform public policy and encourage the most efficient use of resources.

This paper served to respond to one research question, namely: *What are the key determinants for reduction in under-5 mortality in Uganda?*

The results of the statistical analysis indicate three determinants to be significantly associated with under-5 mortality in Uganda: LLIN ownership, wealth status and mother's education. I tested these three determinants along with a fourth – sanitation - using a variation of an Oaxaca-Blinder decomposition analysis to further test these determinants. The results of the decomposition analysis indicate that LLIN ownership explains the largest part of the observed decline in under-5 mortality in this sample.

LLIN ownership is a proven cost-effective measure to promote child health and combat under-5 mortality. The results therefore support the hypothesis laid out in chapter 2, namely: Well-known and cost effective public health measures have contributed to the decline in under-5 mortality in Uganda.

While the decomposition analysis showed LLIN ownership to explain the largest part, it is interesting to note the two other factors shown to be significantly associated with under-5 mortality in Uganda, in the logistic regression model: wealth status and mother's education. As shown in chapters 6 and 7, these two factors are key in the most commonly used economic models to study under-5 mortality and have been found in research to be among those most strongly correlated with child health.

The fact that LLIN ownership is shown to explain the largest part of the decline in under-5 mortality in this sample is of particular interest to me since because of its effect on malaria. The global burden of malaria continues to be immense. According to the World Health Organization (WHO) an estimated 247 million cases of malaria led to almost 881,000 deaths in 2006 (World Health Organisation 2008). A majority of malaria deaths occur in sub-Saharan Africa. Despite the significant gains discussed in the introduction, malaria remains one of the leading causes of mortality among children under the age of five, as they have not yet developed sufficient naturally acquired immunity against malarial parasites (UN-IGME, 2007). The risk to pregnant women is of equal interest, since if they are infected with malaria

risk developing malarial anemia, which is closely correlated with low birth weight of children. The use of LLINs is widely considered a highly effective intervention; various community-based trials and studies show that LLIN use cuts malaria transmission and reduces malaria-related morbidity and all-cause under-5 mortality in a variety of study settings (Barreca et al. 2010, Lengeler 2004, Hay et al. 2004).

The cost-effectiveness of LLINs as a means to prevent malaria has also been shown in several studies. White et al. (2011) show that for a mere $2.20 (range $0.88-$9.54) per year one person could be protected with an ITN (Goodman et al. 1999, Hanson et al. 2004).

In Uganda, the proportion of households with at least one LLIN increased from 47% in 2009 to 59% in 2011 following public mass campaigns. An interesting area for follow-up of this analysis, specifically for Uganda, will be to use data that captures LLIN ownership following the mass campaign in 2014 where the Uganda Ministry of Health (supported by the President's Malaria Initiative (PMI), Global Fund for AIDS, Tuberculosis and Malaria (GFATM), the UKAID Department for International Development (DFID) and Malaria Consortium) (2015) distributed over 22 million LLINs to 40 million registered users. It would therefore be interesting to further analyse the effect of LLIN ownership, since it has been documented that net coverage begins to drop at a rate of 5-13 percent per year (USAID 2015).

An interesting area for behavioural and socio-economic research, concerns the use of nets. Ownership of a net does not necessarily mean consistent use, and the increased and consistent use could help ensure the benefit of this child health interventions. In a DHS working paper from 2008, Khan et al. identify differentials in use by age. While this study found that children under age 5 consistently had higher use of nets than persons age 5-14 or 15-19, several studies looking at socio-economic, demographic, and cultural predictors of LLIN ownership and use show that access to health care, education, and wealth predicts LLIN ownership and use, and that number of children in a household also predicts LLIN use; children of mothers who have several children are more likely to use LLINs than children whose mothers have fewer children, and older children are less likely than younger children to use ITNs (Schellenberg et al. 2001).

Decomposition analysis remains interesting as a tool for analysis of factors underlying variance in a key characteristic between two points in time. However, the explained part is smaller than I had hoped. 22.6% of the observed decline in under-5 mortality can be explained statistically by the three factors of LLIN ownership, wealth status and mother's education level, and only 17% of the observed decline can be explained by the increase in ownership of LLINs. The decomposition analysis alone should therefore not alone suggest that LLIN ownership is the key determinant for the observed decline in under-5 mortality. However, the decomposition analysis can be considered additional confirmation for the positive contribution of LLIN ownership to the reduction in under-5 mortality, particularly given the support in research and theory as well as the results of the logistic regression.

It is worth noting that perhaps this type of decomposition analysis is not best suited for analysis of under-5 mortality determinants, given the complexity of the potentially underlying interrelated characteristics. Demombynes and Trommlerová in their 2012 paper use the Oaxaca-Blinder

decomposition to analyse the drivers behind the decline in infant mortality in Kenya. It may have been more appropriate because the time lag between birth and death is shorter for infant mortality and the assumptions therefore stronger. The long time lag involved for under-5 mortality opens for uncertainties and impact from other contextual inter-related factors. Also, in Kenya they have seen a larger decline in infant mortality than the child mortality in Uganda; where there is a large set of interrelated factors contributing to a small change in the dependent variable, the explained part will be smaller and the determinants less easy to identify.

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