Short interpregnancy intervals and child survival

Ph. D. Thesis
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Preface

The work presented in this PhD thesis was carried out both at the Department of Epidemiology and Social Medicine, Aarhus University and in Uganda at the Child Health and Development Centre.

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I am very grateful to my friend and mentor, Dr Tom Barton, for kindling and nurturing the spirit of research in me and supporting my family in many ways during my absence.

Finally my deepest gratitude to my wife Jolly, and my sons Philip, Mark and Jesse for their patience, support, and encouragement during the long periods of absence both in the field and in Denmark.

Financial support for this work was obtained from DANIDA through the ENRECA programme.

Aarhus, September 2001
The thesis is based on the following papers and a brief communication:


## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>Body Mass Index</td>
</tr>
<tr>
<td>CHDC</td>
<td>Child Health and Development Centre</td>
</tr>
<tr>
<td>DANIDA</td>
<td>Danish International Development Agency</td>
</tr>
<tr>
<td>DHS</td>
<td>Demographic and Health Survey</td>
</tr>
<tr>
<td>ENRECA</td>
<td>Enhancement of Research Capacity</td>
</tr>
<tr>
<td>IMR</td>
<td>Infant Mortality Rate</td>
</tr>
<tr>
<td>IUGR</td>
<td>Intrauterine Growth Retardation</td>
</tr>
<tr>
<td>LBW</td>
<td>Low Birth Weight</td>
</tr>
<tr>
<td>MCH</td>
<td>Maternal and Child Health</td>
</tr>
<tr>
<td>NNM</td>
<td>Neonatal Mortality</td>
</tr>
<tr>
<td>PTB</td>
<td>Preterm Birth</td>
</tr>
<tr>
<td>SES</td>
<td>Socio-economic status</td>
</tr>
<tr>
<td>SGA</td>
<td>Small-for-gestation age</td>
</tr>
<tr>
<td>TORCH</td>
<td>Tororo Community Health</td>
</tr>
<tr>
<td>WFS</td>
<td>World Fertility Survey</td>
</tr>
</tbody>
</table>
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Map showing location, population density, and health facilities of Bunyole, Tororo District 1999.
1. Introduction

The timing of births involves both biological and socio-cultural processes. The biological processes include fecundity, ovulation and spermatogenesis, gestation and delivery of a normal child, and lactational infecundability. Socio-cultural processes include behaviour that limits ovulation, those that avoid pregnancy, or those that promote childbearing. Although some variation in the biological processes exists, socio-cultural factors play a major role in the pace of childbearing. Birth spacing is an important determinant of the rates of population growth and has a strong bearing on maternal and infant health. A different mix of mechanisms causing either short or long intervals may represent women or families with different bio-demographic and social risk profiles for short and long intervals. The distribution of and reasons for short and long intervals varies considerably among populations and health effects of short intervals are not the same for all populations. Specific reproductive health policies and programming are needed to address these differences. It is therefore important to know the specific factors and circumstances that determine, and the outcomes that follow, short birth intervals in any given population.

1.1. Definition of birth interval

Researchers determining factors that affect fertility and fertility outcomes have used various definitions of birth interval. Definitions range from the interval between two consecutive live births (interbirth interval), to the interval between the outcome of one pregnancy and the conception of the next (birth-to-conception interval), to the interval between two consecutive pregnancies (interpregnancy interval), and the number of births within a given time frame (average birth interval). Different definitions are used because they are appropriate in different situations. For example, surveys done among populations unsure of conception dates use interbirth intervals, register-based and cohort studies use either pregnancy or birth-to-conception intervals. Thus, lack of a uniform definition of pregnancy intervals presents a problem in interpreting and comparing studies. The definition of a short birth interval has varied among studies principally due to the interval definition (birth-to-conception or interpregnancy interval), and the pregnancy outcomes being studied. An “optimum” birth interval is defined as the interval associated with the greatest probability of giving birth to a normal full term infant and with the lowest risks of adverse outcomes to the mother and the preceding child. Short birth-to-conception intervals have ranged from three months to 18 months while studies using Demographic and Health Survey (DHS) data consider an interbirth interval less than 24 months short. On the other hand, long intervals, greater than 100 months are also associated with an increased risk of adverse pregnancy outcomes.
1.2. Components of birth interval
To understand the variation and effects of birth spacing, one needs to understand the determinants of human fertility and reproduction. Women will produce a certain number of children by the end of their reproductive lifetimes because of the way in which they time the various reproductive events. Figure 1 depicts the female reproductive life course as a series of time intervals. Menarche signals the beginning of fecundity (the biological capacity to reproduce) while marriage represents all women living in sexual union or are having regular sexual intercourse. Following pregnancy, a woman will remain infecundable until the normal pattern of ovulation and menstruation is restored.

Figure 1. A female reproductive life course viewed as a series of time intervals.9

The time spent in different reproductive states will cause interpopulation and intrapopulation variation in fertility. However, a number of factors determine the time spent in each of these intervals.
Initially, Davis and Blake10 described a framework that mainly considered the socio-cultural factors that affected the three necessary steps of human reproduction: intercourse, conception, and pregnancy (gestation and parturition). This was later modified and quantified by Bongaarts.11 The frameworks consider that if any factor is to affect fertility, it must do so through its effect on one or more of the “proximate determinants” or “intermediate fertility variables”. Figure 2 shows another framework that considers biological determinants as well. The exposure factors determine the probability of conception while the susceptibility factors govern the conditional probability of successful reproduction, given that the exposure occurs.9 Thus, after menarche and before menopause, fertility will depend on factors that affect fecundability, defined as the probability that a fecund couple will conceive during the month of exposure to unprotected intercourse.
Figure 2. The proximate determinants of natural fertility

Proximate determinants exert a direct effect on each of time intervals because they determine the length of these intervals. Figure 3 shows that a birth interval is composed of three periods that can be modified by biological and behavioural factors. The postpartum infecundable period is a period between the delivery and first postpartum ovulation. This period is lengthened by lactational behaviour and nutritional status of the mother. The fecund waiting time to conception, also called the fecundable period, occurs from the first postpartum ovulation to conception. Fecundity depends on ovum viability and sperm capacity to fertilise. Sexual activity patterns including low frequency of sexual intercourse and postpartum abstinence, and use of contraception would prolong birth intervals. Although gestational length is an important determinant for foetal viability, variation in the gestational length is unlikely to be a major cause of variation in interval length except for the very short intervals. In some cases prolonged birth intervals are due to time added by a pregnancy loss.
It is also known that factors that affect fertility will also affect child survival. Mosley and Chen proposed an analytical framework to study the determinants of child survival in developing countries that suggests that all social and economic determinants must operate through a set of intermediate determinants, which will directly influence the risk of morbidity and mortality. These determinants have been divided into five categories of which birth interval is an important determinant of the ‘maternal factors’ category.

### 1.3. Magnitude of the problem of short birth intervals

The overall public health importance of short interpregnancy interval is determined not only by the risks for mortality and morbidity of the preceding child, subsequent child, and the mother, but also by the prevalence of short intervals in the population.

#### 1.3.1. Prevalence of short birth intervals

Since most research in developed countries has focused on the association between short birth intervals and adverse perinatal outcomes, different cutoff points for short birth intervals have been used. The prevalence of short birth intervals range from 5-30\%.\(^5\,^6\,^8\,^22\,-\,^24\)

World Fertility Survey and later the Demographic and Health Survey (DHS) are nationally representative cross-sectional surveys, mainly carried out in developing countries, to study fertility and demographic changes. In these surveys, an interval less than 24 months is considered short. However, the prevalence of short interbirth intervals of less than 18 months, which is comparable to a birth-to-conception interval of 9 months, also ranges from 6-24\%.\(^7\)

#### 1.3.2. Short birth intervals and risk for adverse pregnancy outcome

**Abortion**

Studies from developed countries suggest that both short and long birth intervals are
associated with spontaneous abortion in the subsequent pregnancy, especially if the interval is less than six months or longer than 60 months.\textsuperscript{25,26} The risk of spontaneous abortion following an induced abortion was increased if the mother became pregnant within three months of the procedure.\textsuperscript{27}

\textit{Low birth weight, preterm birth and small-for-gestational age}
Meta-analysis of studies from 1970-1984 on low birth weight (LBW) has shown that the effect of short birth intervals on low birth weight is inconclusive, but also that the short birth intervals may not be an important cause of intrauterine growth retardation (IUGR) in the United States, where most of the reviewed studies were carried out.\textsuperscript{28} Recent studies are still inconclusive, but more studies show a positive association between short birth intervals and low birth weight,\textsuperscript{22,29} preterm birth,\textsuperscript{5,6,8} and small-for-gestational age,\textsuperscript{30-33} while others show little or no association with some of these outcomes.\textsuperscript{34,35} The risk for these adverse outcomes was increased and ranged from 1.2 to more than 3.0. The risk was high in some developing countries\textsuperscript{36} and slightly lower in the developed countries.\textsuperscript{22} The LBW outcomes were curvilinear with a high risk for the short and very long intervals in United States\textsuperscript{37} and India.\textsuperscript{38} Table 1 presents more recent studies that show the large variation in prevalence and effects of short interpregnancy intervals on adverse pregnancy outcomes in developed countries.
Table 1. Summary of selected major cohort studies of association between short birth intervals and adverse pregnancy outcomes

<table>
<thead>
<tr>
<th>Author</th>
<th>Country Population Study year</th>
<th>Study Design</th>
<th>Exposure Birth interval (months)</th>
<th>Confounder control</th>
<th>Ref. Interval (months)</th>
<th>Prevalence % [Cut-off point in months]</th>
<th>Key results: Adverse pregnancy outcome (OR or RR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basso, O</td>
<td>Denmark 10,187 1980-92</td>
<td>Historical cohort</td>
<td>BCI (&lt;4) (&gt;8)</td>
<td>MA</td>
<td>24-36</td>
<td>5.5 [8]</td>
<td>1.0 ns</td>
</tr>
<tr>
<td>Fuentes-Afflick</td>
<td>USA 289,842 1991</td>
<td>Cohort records review</td>
<td>BCI (&lt;18) (&gt;8)</td>
<td>MA</td>
<td>18-59</td>
<td>36.9 [18]</td>
<td>1.2</td>
</tr>
<tr>
<td>Miller JE</td>
<td>Sweden 92,084 1973</td>
<td>Cohort</td>
<td>IPI&lt;12</td>
<td>MA</td>
<td>18-59</td>
<td>19.5 [6]</td>
<td>1.0 ns</td>
</tr>
<tr>
<td>Rawlings JS</td>
<td>USA 1922 1983-93</td>
<td>Cohort</td>
<td>BCI (&lt;6) BW BCI (&lt;9) WW BCI (&lt;3)</td>
<td>Race</td>
<td>≥6</td>
<td>19.5 [6]</td>
<td>1.0 ns</td>
</tr>
<tr>
<td>Schults RA</td>
<td>USA 34,569 1988-94</td>
<td>Cohort records review</td>
<td>BCI (≤3)</td>
<td>Marital status</td>
<td>13-24</td>
<td>3.2 [12]</td>
<td>1.2</td>
</tr>
<tr>
<td>Wohlfahrt J</td>
<td>Denmark 181,483 1988-92</td>
<td>Cohort Register based</td>
<td>IPI (&lt;6) (&gt;60) (&gt;120)</td>
<td>MA</td>
<td>18-23</td>
<td></td>
<td>Abortion</td>
</tr>
<tr>
<td>Zhu, BP</td>
<td>USA 173,205 1989-96</td>
<td>Cohort records review</td>
<td>BCI (&lt;18)</td>
<td>16 factors</td>
<td>18-23</td>
<td>5.4 [6]</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Child mortality

The relationship between birth interval and neonatal, infant and childhood mortality has been extensively studied using data from World Fertility Surveys, Demographic Health Surveys, and household survey data obtained from a number of developed and developing countries. Table 2 presents selected studies from developed countries that consistently show that short birth intervals are associated with an increased risk of neonatal, post neonatal, and early childhood mortality. The association between short birth intervals and perinatal mortality is strong even after controlling for length of gestation, previous child mortality, and other potential confounders. Child mortality trend studies show that despite reduction of child mortality and some associated risk factors decreasing, short birth interval levels have remained unchanged. Given the consistent association between short birth intervals and child mortality, reduction in short birth intervals would have a great impact on reducing child mortality.

Other adverse childhood outcomes

Child mortality and adverse pregnancy outcomes aside, few studies show long-term adverse effects of short birth intervals on child growth and development. The effects on the preceding or index child’s development vary amongst populations. In Nepal, the linear growth of the preceding child reduced by 28% following short interpregnancy intervals, while there was no effect on child growth in a Kenyan population. Another study identified short interpregnancy interval as a consistent prenatal factor that increased the risk for cerebral palsy. In Singapore, children born after short birth intervals scored lower verbal and perceptive tests than those born after a long birth interval. Short birth intervals accounted for 39% of the variation in the Mill Hill vocabulary test. The same study showed a positive linear effect of gradual improvements with increase in birth interval.
Table 2. Summary of selected major studies from developing countries of association between short birth intervals and child mortality

<table>
<thead>
<tr>
<th>Author</th>
<th>Publication Year</th>
<th>Country Population Study year</th>
<th>Study Design</th>
<th>Exposure Birth interval (months)</th>
<th>Confounder control</th>
<th>Ref. Interval (months)</th>
<th>Key results: Child mortality (RR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koenig</td>
<td>1990</td>
<td>Bangladesh 11,454 births 1973-78</td>
<td>Cohort (DSS)</td>
<td>PBI&lt;24 SBI&lt;24</td>
<td>Child Gender, MA, Parity, SES, M Ed</td>
<td>24-36</td>
<td>NNM: 1.5 PNM: 1.2 ns IM: 1.3 ns</td>
</tr>
<tr>
<td>Boerma</td>
<td>1992</td>
<td>17 Developing countries 1986-89</td>
<td>Cohort</td>
<td>BCI&lt;12 BCI&gt;60</td>
<td>GA, MA, Child gender</td>
<td>24-35</td>
<td>NNM: 1.8 PNM: 1.3 IM:</td>
</tr>
<tr>
<td>Hobcraft</td>
<td>1983</td>
<td>26 countries 140,100 1974-80</td>
<td>Cross-sectional survey (DHS)</td>
<td>PBI&lt;24</td>
<td>M Ed, MA</td>
<td>24-35</td>
<td>NNM: 1.5-3.4 PNM: 1.1-7.2 IM: 0.8-3.9</td>
</tr>
<tr>
<td>Rutstein</td>
<td>56 developing countries 1986-1998</td>
<td>Repeated Cross-sectional</td>
<td>PBI&lt;24</td>
<td>17 factors</td>
<td></td>
<td>0.8/1000*</td>
<td>PNM: 1.1/1000* IM:</td>
</tr>
</tbody>
</table>

1.3.3. Short birth intervals and maternal outcome

The few studies carried out to determine the effect of short intervals on the mother are inconclusive. Table 3. presents results of some studies that consider the effects of short intervals on maternal morbidity and mortality. It has been postulated that short birth intervals and prolonged lactation worsen maternal nutritional status. Some studies demonstrate an increase in maternal weight with parity, but a cohort study in Pakistan suggested that maternal depletion occurs and may cause poor reproductive outcomes.

Short interpregnancy intervals were associated with maternal postpartum depression and an increased risk of uterine dehiscence or rupture during trials of labour following a previous Caesarean delivery.

The effect of birth intervals on maternal mortality is inconclusive with higher risk of death in some studies based on hospital records and no effect in others surveys.
<table>
<thead>
<tr>
<th>Author</th>
<th>Publication Year</th>
<th>Country/Population Study Year</th>
<th>Study Design</th>
<th>Exposures Birth interval (in months)</th>
<th>Outcomes</th>
<th>Confounder control</th>
<th>Key results (OR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conde-Agudelo</td>
<td>2000</td>
<td>Latin America 456,889 1985-1997</td>
<td>Cross-sectional study</td>
<td>IPI (&lt;6)</td>
<td>Maternal morbidity and mortality</td>
<td>16 major obstetric confounders</td>
<td>Increased risk of maternal death (OR 2.5); Anaemia (OR 1.3) Third trimester haemorrhage (OR 1.7); puerperal endometritis (1.3)</td>
</tr>
<tr>
<td>Esposito MA</td>
<td>2000</td>
<td>USA 170 [43 cases 127 controls] 1990-1999</td>
<td>Case-referent</td>
<td>BCI (&lt;6)</td>
<td>Uterine scar failure / Uterine rupture</td>
<td>MA Parity Use of cervical ripening agents in labour</td>
<td>Increased risk for uterine scar failure (OR 3.9)</td>
</tr>
<tr>
<td>Fortney JA</td>
<td>1998</td>
<td>Multiple 377 cases, 1420 controls 1977-1993</td>
<td>Case-referent Matched case-referent</td>
<td>BI (&lt;24)</td>
<td>Maternal mortality</td>
<td>Identified but not reported Non significant association, Significant trends of maternal death with shortening IPI (1-2.4 for BI &lt;12 months)</td>
<td></td>
</tr>
<tr>
<td>Gurel SA</td>
<td>2000</td>
<td>Turkey 85 Not reported</td>
<td>Case-referent IPI (&lt;24)</td>
<td>Depression BDI &gt; 17</td>
<td>M Ed Parity Congenital Abnormality Unwanted pregnancy</td>
<td>Associated with moderate to severe depression (OR 6.8)</td>
<td></td>
</tr>
<tr>
<td>Miller JE</td>
<td>1989</td>
<td>Lesotho 873 1982</td>
<td>Cross-sectional study</td>
<td>IBI (&lt;12)</td>
<td>Maternal nutrition BMI, Triceps thickness Arm muscle area</td>
<td>MA Parity Pregnancy status</td>
<td>Short birth interval associated with short term maternal depletion Nutritional Indices lowest at 18-23 months Arm muscle area significantly reduced at 12 months</td>
</tr>
<tr>
<td>Shipp</td>
<td>2001</td>
<td>USA 2409 1984-1996</td>
<td>Cross-sectional study</td>
<td>IBI (&lt;18)</td>
<td>Symptomatic Uterine Rupture</td>
<td></td>
<td>Increased risk for uterine scar failure OR (3.0)</td>
</tr>
<tr>
<td>Smits</td>
<td>1999</td>
<td>Canada 2062 1850-99</td>
<td>Historical cohort</td>
<td>BCI (&lt;6)</td>
<td>Fertility among daughters</td>
<td>Husband’s age and occupation Daughters age Preceding child survival</td>
<td>Higher risk for conception failure if daughter delivered after short interval (OR 1.1) Highest fertility among daughters born in winter</td>
</tr>
</tbody>
</table>

1.3.4. Preceding and subsequent birth interval
Two time periods have to be considered in birth interval research. The preceding birth interval is the period between the previous pregnancy and the index childbirth, while the subsequent interval is the period between the index childbirth and the next pregnancy.

Intervening processes through which preceding or subsequent birth intervals operate to influence the survival chances of the child are still unclear. Most studies consider the effect of preceding birth interval on child survival. Fewer studies consider the effect of the subsequent birth interval on child survival because of the difficulty of determining the cause-effect relationship, since accurate dates on weaning and death of the index child are usually not available.\textsuperscript{2,39,68}

1.3.5. Theoretical concepts of birth interval and adverse pregnancy outcomes and child survival
Five hypotheses have been postulated to explain the association between birth intervals and adverse pregnancy outcomes.

a) Maternal depletion hypothesis: Short birth intervals and increased periods of lactation result in the worsening of maternal nutritional status, because the short time does not allow the mother’s body full physiological recovery.\textsuperscript{40,58,59} This causes a hostile intrauterine environment, which increases the likelihood of poor reproductive outcomes (low birth weight, prematurity, intrauterine growth retardation).

b) Sibling competition: Closely spaced births lead to two children of roughly the same size and age, and consequently to reduced family care and support for both or one of the children. They will share the meagre family resources which, in turn, may lead to increased morbidity and mortality among the children.\textsuperscript{57}

c) Disease transmission hypothesis: Increase in the number of children in a home will increase the likelihood of acquiring transmissible diseases, which may lead to increased morbidity and mortality among children.\textsuperscript{59}

d) Breast feeding hypothesis: shortened breast feeding periods, early weaning, and less maternal support to the preceding child may lead to increased morbidity and mortality in the preceding child.\textsuperscript{46,70}

e) Preovulatory overripeness of the oocyte: It is hypothesised that females, conceived in a condition of maternal endocrine irregularities, face an increased risk of ovarian dysfunction through overripeness-induced gonadal maldevelopment.\textsuperscript{71}

Figure 4 depicts the intervals where some of the postulated mechanisms may act. Biological determinants which include prematurity, intrauterine growth retardation, and impaired lactation, are more likely to influence the preceding interval while behavioural factors are more likely to influence the subsequent interval.
Figure 4. Postulated mechanisms for the association of short birth intervals and poor pregnancy outcomes and the birth intervals they may influence.

The evidence for maternal depletion and maternal nutritional status on fertility and reproductive outcomes is inconclusive. Short interpregnancy intervals may have an impact on the nutritional status of the mother and on the mechanical properties on hysterotomy wound healing. Although the time required for peak myometrial strength to return after hysterotomy is not well known, a short inter-delivery interval, less than 12 months, is an important risk factor for uterine rupture or scar dehiscence in the subsequent pregnancy.

Studies show the increased risk of preceding child mortality, support the sibling competition hypothesis. However, some studies show that the risk of death of the index child was still high despite previous child death with death clustering observed in families which may support the disease transmission hypothesis.

Overripeness ovopathy may be supported in part by the increased risk of menstrual disturbances among daughters born to women conceived after the short interpregnancy interval, increased risk of spontaneous abortion and increased adverse pregnancy outcomes following short intervals.

1.4. Short birth interval as an outcome

One suggested hypothesis explaining the association between birth intervals and poor perinatal health is the selection hypothesis. The selection hypothesis suggests that “the increasing health risks observed among foetuses conceived shortly after the preceding birth are not attributable to short spacing per se, but to the over representation of this group of women, who are at high risk of bearing unhealthy infants for reasons other than short conception intervals”.

Thus, a given maternal characteristic/variable should be strongly associated with both short birth intervals and adverse perinatal outcomes. Some studies have shown that previous reproductive loss, maternal age, race and maternal social status are important predictors of both short birth intervals and adverse perinatal outcome. Similarly, one study has shown that there is a tendency to repeat
gestational age and birth weight in successive pregnancies even after controlling for
the interpregnancy interval, foetal loss, and onset of labour. However, the
contributions of these factors to “causing” short birth intervals or adverse pregnancy
outcomes differ from population to population. For example, Park developed a two
tier causal model, which shows that birth order, survival status of the preceding child,
and short birth intervals had direct roles in increasing infant mortality risk. The
effects of maternal age, maternal education, and birth order were mediated through
the preceding birth interval.

1.5. Social-economic status and birth interval
An important risk factor for short birth intervals is the social-economic status of the
mother. Social class was measured either as a unitary concept with all indicators
measuring the same concept or multidimensional with different social class indicators
measuring multiple aspects of social class. Social economic status (SES) has been
defined as “a composite measure that typically incorporates economic status,
measured by income, social status, measured by education and work status measured
by occupation.” Measures of social class can be grouped according to each of the
three single indicators commonly used (occupation, education, and income) or can be
used as composite index measures. Reviews on social class, socio-economic status or
socio-economic position in epidemiological and public health literature show that
many studies include some measure of social class. SES was considered either as
a confounder, a risk factor, or a descriptive variable of the study sample. Education
was the most frequently used measure followed by occupation, and composite
measures. Of all the SES measures, education has the advantage of being the
simplest to collect, is stable over ones lifetime, reasonably accurate, and is associated
with lifestyle characteristics and health behaviour. Unfortunately, the bulk of
research on defining and measuring SES derives from studies in developed countries.
Some of the measures emphasise occupational standing, which is difficult to
determine in developing countries, as most people are self-employed in agriculture or
unemployed. A number of studies have developed amenity scores used for their
specific studies but these are usually population and study specific.

Despite different measures of SES, the role of SES in increasing the risk of short
birth intervals differs among the different populations studied. Most studies show a
negative association between SES and adverse pregnancy outcome and short birth
intervals, but the association between SES and birth intervals ranges from negative to
no association.
2. Aims of the thesis

Given the large variation in risk factors associated with short interpregnancy intervals among populations, the overall aim of this thesis was to identify which women are more likely to have short birth intervals, under which circumstances, and for what reasons.

The thesis is based upon two study populations; one from rural Uganda and the other from Denmark.

The specific aims of the thesis are:

a) To determine risk factors associated with short interpregnancy intervals in a rural population in Uganda.

b) To determine short interpregnancy interval and other risk factors associated with child mortality in a rural Ugandan population.

c) To determine risk factors associated with short interpregnancy intervals in Denmark.
3. Materials and Methods

3.1. Uganda

3.1.1. Country description
Uganda is a landlocked country in East Africa, and covers an area of 241,039 square kilometres. Administratively, Uganda is currently divided into 56 districts, each of which is further divided into counties, subcounties, parishes, and villages. The majority (86%) of the estimated 20.9 million people live in rural areas. Uganda’s average population density is 105 persons per sq km, but this varies widely from 38 to 301 persons per sq km among rural districts. The average population growth rate is 2.5% per year, but this also varies from –0.93 to 5.9 in the different districts.\(^8\)

Uganda is one of the poorest nations in the world and is ranked 141st on the human development index. This index, developed by UNDP, considers three basic dimensions of human development: life expectancy, adult literacy and per capita gross domestic product.\(^9\) In 1999, about 37% of the population lived on less than a dollar a day, the annual per capita gross national product (GNP) is estimated at 320 US $ and 35% of the adults were illiterate.\(^1\)

Participatory poverty assessment studies in Uganda show that poverty is dynamic and changes over time. The most frequent causes of poverty include poor health, excessive alcohol consumption, large families, lack of education and employable skills, and limited access to financial services, capital or markets.\(^2\) Table 4 shows some socio demographic and health indicators for Uganda with high child and maternal mortality, high fertility, low life expectancy, and poor access to health services.
### Table 4. Selected demographic, socio-economic and health indicators for Uganda

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Uganda</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic</strong></td>
<td></td>
</tr>
<tr>
<td>Projected total population, 1999 (millions)</td>
<td>21.6</td>
</tr>
<tr>
<td>Annual population growth rate (1980-1991)</td>
<td>2.5</td>
</tr>
<tr>
<td>Population density (per sq. km)</td>
<td>105</td>
</tr>
<tr>
<td>Percent female 15-49 years (1991)</td>
<td>43.5</td>
</tr>
<tr>
<td>Percent children 0-14 years (1991)</td>
<td>47.3</td>
</tr>
<tr>
<td>Male life expectancy at birth (years) 1999</td>
<td>43</td>
</tr>
<tr>
<td>Female life expectancy at birth (years) 1999</td>
<td>42</td>
</tr>
<tr>
<td><strong>Mortality (1995)</strong></td>
<td></td>
</tr>
<tr>
<td>Infant mortality rate (per 1000 live births)</td>
<td>97</td>
</tr>
<tr>
<td>Under five mortality rate (per 1000 live births)</td>
<td>147</td>
</tr>
<tr>
<td>Maternal mortality ratio (per 100 000 live births)</td>
<td>506</td>
</tr>
<tr>
<td><strong>Socio-economic</strong></td>
<td></td>
</tr>
<tr>
<td>Per Capita GNP US $ (1998)</td>
<td>320</td>
</tr>
<tr>
<td>Prevalence of child malnutrition (1995)</td>
<td>26</td>
</tr>
<tr>
<td>Radio (per 1000 people)</td>
<td>123</td>
</tr>
<tr>
<td>Percent of male adults literate (1997)</td>
<td>73</td>
</tr>
<tr>
<td>Percent of female adults literate (1997)</td>
<td>47</td>
</tr>
<tr>
<td><strong>Reproductive health</strong></td>
<td></td>
</tr>
<tr>
<td>Total fertility rate per woman (2000)</td>
<td>6.9</td>
</tr>
<tr>
<td>Contraceptive prevalence rate (2000)</td>
<td>20</td>
</tr>
<tr>
<td>Percent births within 24 months of a previous birth(1995)</td>
<td>27.8</td>
</tr>
<tr>
<td>Percent deliveries supervised by skilled personnel (2000)</td>
<td>38</td>
</tr>
<tr>
<td><strong>Access to health services (1997)</strong></td>
<td></td>
</tr>
<tr>
<td>Population: doctor ratio</td>
<td>20,228</td>
</tr>
<tr>
<td>Population: midwife ratio</td>
<td>7,431</td>
</tr>
<tr>
<td>Percent population with access to health units</td>
<td>49</td>
</tr>
</tbody>
</table>

Sources:
89-91, 93-95

In trying to address some of these problems, the Ugandan government over the last five years introduced universal free primary education for children to improve literacy rates, designed a poverty eradication action plan to address some causes of poverty, and developed a health policy and strategic plan with the aim of reducing morbidity and fertility.95,96 The 2001-2005 health sector strategic plan sets out to deliver services through implementing a minimum health care package that addresses the major causes of morbidity and mortality in Uganda and strengthening the health
support systems mainly through decentralisation of the health services.\textsuperscript{94,97}

3.1.2. Study area
Bunyole health sub-district in Tororo district is about 260 km east of the Ugandan capital, Kampala. It is administratively divided into six subcounties and 21 parishes. The estimated size of Bunyole is 644 sq. km and the estimated population in 1999 was 134,000. The population density varies between the six subcounties (Map1). Subsistence agriculture is the main economic activity for 83\% of the working population. Food crops grown include cereals and legumes, while coffee and cotton are grown as cash crops. Rice is grown in some of the reclaimed swamp areas. Non-commercial livestock management is the second most important activity in Bunyole and cows, goats, sheep, and poultry are reared as a source of income, as food, and for prestige. The average family land holdings are about 2.2 hectares.\textsuperscript{98}

Bunyole has one hospital and six health units. In 1999, the staff establishment that were directly involved in maternal health services included three doctors, 13 midwives (nine of who work at the hospital), 71 trained traditional birth attendants, 30 Community Reproductive Health Workers and many other untrained traditional birth attendants. The district health team is involved in training more traditional birth attendants and community health workers.

3.1.3. Study design
Figure 5 presents the study design which included two phases: an initial cross-sectional survey used to identify all pregnant women and a follow-up study to determine the factors associated with short interpregnancy intervals.

The sample size was calculated using the largest estimated sample for the smallest outcome measure for the study, a relative risk worth detecting of 2, a 1:2 ratio of the exposed to unexposed, and a study power of 80\% and 95\% confidence level, and allowing for a 10\% dropout from the study. The required sample size was 700 mothers with short interpregnancy intervals (exposure) and a control group of 1400 unexposed mothers.\textsuperscript{99}
Figure 5. Design for recruitment and follow up of mothers in Bunyole health sub district, Uganda 1999

Cross-sectional study

The cross-sectional survey was carried out in April and May 1999 in all parishes in the project area. Data were collected through house-to-house interviews on a predetermined date in all parishes. All pregnant multigravidae and those who had delivered during the data collection month and were resident in the survey area were eligible for recruitment. Twenty local female health workers were trained for one week to collect the data using a pretested questionnaire. Training included translating the questionnaire into the local language, back-translation of the questionnaire to English, and using a gestation age calculator designed for the study. The questionnaire was designed to collect information on child mortality using the preceding birth technique. The date and outcome of the last pregnancy, the status of the child if born alive, and the date of death, had the child died, were also obtained. The interviewers used a field manual to maintain consistency of data collection, and a birth interval calculator to reduce arithmetic errors (Appendix 4: Letter 1). Two supervisors monitored the data collection process by spot checks and monitoring the interviews.
**Cohort study**

From June to December 1999, six teams, each comprising of a midwife and community health worker, identified eligible mothers from the cross-sectional study. Each team was assigned to specific subcounties and interviewed participants either at home or at antenatal sessions held at the six health units in the study area. The baseline questionnaire, which was administered in the initial three months of the study, included core questions on fertility, socio-economic status, and maternal history also used in the DHS.

Follow-up interviews were carried out at the participants’ homes. Mothers and traditional birth attendants who attended to them at delivery were asked to inform the research team on delivery, so that the first postnatal interview could be carried out soon after delivery. Follow up interviews collected information on the delivery and current status of the mother and child.

3.1.4. **Outcome measures**

The outcome variable was the preceding interpregnancy interval. The preceding interpregnancy interval was defined as the period from date of birth of the previous pregnancy, irrespective of the outcome, to the date of birth of the recently concluded pregnancy. For comparability to the DHS and other studies in developing countries, an interval less than 24 months was considered as a short interval. While this corresponds to a 15-month birth-to-conception interval, birth-to-conception interval estimation is unreliable in developing countries because most mothers are either unsure of their menstrual dates, may have lactational amenorrhoea, or the gestational age is not usually known.

Child mortality was defined as the proportion of children born alive who were dead at the time of interview.

3.1.5. **Risk factors**

The risk factors studied were maternal age, parity, marital status, education, socio-economic status measured by the domestic animal score and the amenity score, husband’s education, lactation patterns, previous pregnancy outcome, antenatal attendance, residence, and ethnic group.

3.1.6. **Ethical considerations**

In Uganda, ethical clearance was obtained from the Uganda National Council of Science and Technology. District health authorities gave permission to carry out the study in their area, and mothers gave their informed consent to participate in the study. Sick mothers were referred to hospital for treatment, and mothers could stop participating in the study when they so desired.

3.2. **Denmark**

To study the determinants of short interpregnancy intervals in Denmark, data from a population-based study that studied the social risk factors and pregnancy outcomes were used.
3.2.1. Data sources
The data used were collected in a population based cohort study of pregnant women in two counties in Denmark who were recruited for a health behaviour community trial. The study obtained information about potential risk factors for adverse pregnancy outcome from pregnant women residing in two cities in Denmark. From April 1984 to April 1987, a self-administered questionnaire about the mothers current lifestyle was given to all pregnant women within the geographical area of Odense and Aalborg cities attending a routine antenatal visit in the 36th gestational week. In 1987, Odense and Aalborg had a total population of 250,036. More than 95% of pregnant women (n=13,815) received the questionnaire, and 11,980 (87%) completed the questionnaire. Obstetric information was extracted from the medical birth records after delivery.

Since 1968, all residents in Denmark have received a unique 10-digit central personal registration number (CPR) from the Civil Registration System. All children born alive in Denmark are given a CPR number which is linked to their mothers. We obtained CPR numbers for the pregnant women in the cohort. Valid CPR numbers were linked at the Civil Population Registry to obtain a complete list of children born to these mothers. Figure 6 shows the linkage process used to obtain information about the preceding birth and develop the cohort for the analysis. This linkage process produced information about all previous live births that mothers had up to the time of birth of the index child. Children born during the study period and matched the date of birth in the questionnaire were identified as the “index” child. The date of birth of the preceding child was also recorded. All key variables had less than 1% missing data except planned pregnancy, of which 5% of the responses was missing. Mothers with twin pregnancy and those who could not be matched in the CPR register were excluded from the study population. Of the 11,980 mothers, only 2904 mothers met the inclusion criteria for the study.
Figure 6. Study design for social determinants of short interpregnancy intervals in Denmark.

3.2.2. Outcome measure
The outcome variable was the preceding interpregnancy interval defined as the period from the date of birth of the previous child to the estimated conception date of the index child. The estimated conception date was determined by subtracting the number of completed weeks of gestation from the date of birth of the index child. An interpregnancy interval was considered short if it was less than nine months. This cut-off point was used because a previous study in Denmark showed adverse perinatal outcomes occurring in mothers with an interpregnancy interval of less than eight months.22

3.2.3. Risk factors
Risk factors studied included maternal age, parity, maternal education, maternal social status, husband’s education, housing, smoking and alcohol consumption in pregnancy.

3.2.4. Ethical considerations
The Regional Committee for Ethics and Science approved the initial study. The National Board of Health, Denmark granted permission to use the data and link it to the CPR registry. Record linkage procedure was carried out in accordance with
guidelines set by the National Board of Health Denmark. The original data file with mothers’ CPR was used. After linkage, each mother and children were given unique identification numbers and all CPR numbers were extracted to a new separate identification file. Analysis was performed using a new file without CPR numbers.

4. Statistical analysis

4.1. Overall methodology

Parametric and non-parametric analyses were used to compare the mean birth interval between risk groups. Stratified analysis and Mantel-Haenszel tests were carried out to control for confounding. The association between the explanatory risk factors and the study outcomes was expressed as crude and adjusted odds ratios. Multivariate logistic regression was used to control for confounding in the two datasets. Continuous variables were recoded into categorical variables and categories considered a priori as low risk were used as reference. Stata 6.0 and PEPI were used in the analyses.

Model building strategy

Full models included all variables considered a priori associated with the outcome of interest and statistically significant at p <0.25 in the univariate analysis. Unimportant variables were identified by examining the Wald statistic for each variable and comparing the estimated coefficients in the model with the coefficient from the univariate model. Unimportant variables were excluded, one by one, if the Wald statistic was not significant at p < 0.05 level and new models fitted. The significance of the variable to the model was determined by comparing the new model to the older larger model using the log-likelihood ratio test. Confounding was also evaluated by considering 10% or more change in estimate in the coefficient. Variables not initially selected in univariate analysis were then added to the model, one at a time, and retained if significant. Plausible interactions were identified, and included in the model, one at a time, and tested for significance using the log-likelihood ratio test. Regression diagnostic plots were drawn to examine for influential observations. Influential covariate patterns were then excluded and models fitted without them and any changes in the estimates noted. Overall assessment of fit of the final model was carried out using Hosmer-Lemeshow statistic.

4.2. Data management

4.2.1. Analysis of the Ugandan dataset

Double entry for the collected data was carried out using EPIIFO 6.04. Consistency and missing data checks were carried out. In the cross-sectional data, we imputed missing data on maternal age (n=43) using the mean age of the mothers of same parity. Missing data on husband’s age was included as a separate category in the analysis. Graphical assessment for digit preference for maternal age was carried out.
Child mortality was estimated as a proportion of deaths of children born alive. This proportion of immediately preceding births dying before the second birth date approximates well with the probability of dying before the second birthday on a standard life table, if the birth interval is approximately 30 months. The study used the preceding birth technique, a robust indirect method for estimating child mortality where vital registration does not exist.\textsuperscript{100,101,109,110} Descriptive analysis for seasonal variation of child mortality was done by plotting proportion of deaths and monthly rainfall patterns for the two years before prior to the survey date. Freedman's non-parametric test for seasonal variation was carried out.\textsuperscript{111}

Figure 7 depicts the variables and modelling strategy used in studying the risk factors for short interpregnancy interval. Of the distal determinants considered, maternal age and parity potentially affect fecundity, marital status and social status are factors that affect exposure to intercourse and cultural value for children. Maternal age was categorised in five-year age groups and maternal education into four groups. A 10-point weighted “amenity score” was developed based on the relative cost and importance of the type of roofing material (3 points), and on ownership of a bicycle (3 points), radio (2 points), or a food storage facility (2 points). A “domestic animal score” was based on the size of the cattle herd and presence of goats, pigs, sheep, and poultry. A “contraceptive knowledge score” considered the number of contraceptive methods spontaneously mentioned by respondents. All three scores and household population size were grouped using tertiles. Antenatal care attendance and gestational age at first visit were used as proxies for health service utilisation.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig7.png}
\caption{Strategy used for building models to study risk factors of interpregnancy intervals in Bunyole, Uganda, 1999}
\end{figure}

The first model included previous pregnancy outcome and all distant determinant
variables that were significant at p < 0.25. The second model fitted excluded previous pregnancy outcome to assess any direct association between the distal determinants and short interpregnancy interval. A third model was fitted with selected dichotomised distant determinants to determine their adjusted attributable risk fraction to short interpregnancy intervals. A sensitivity analysis was performed by fitting two models, one with all mothers, and another without mothers unsure of their menstrual dates. This analysis did not change the estimates for maternal age, or previous pregnancy outcome. Crude and adjusted odds ratios for the association between lactation and short interpregnancy intervals were determined.

We compared previous pregnancy outcome, maternal age, and education characteristics of the eligible mothers not interviewed to those mothers interviewed.

4.2.2. Analysis of the Danish dataset

Analysis of the Danish data was restricted to 2904 mothers, whose preceding interpregnancy interval was less than 37 months. Univariate analysis and the crude odds ratios (with 90% CI) were determined. Explanatory variables were grouped into three major groups: social factors, fertility related factors, and lifestyle factors. Stratified analysis was carried out in each of the three major groups to assess confounding within the groups and to select all variables that showed statistical association with short interpregnancy intervals. The full model included all variables that were statistically significant in all groups and those considered a priori to be associated with poor reproductive outcomes such as maternal education. A variable with change in the OR estimate of more than 10% was considered in the reduced model.
5. Results

5.1. Short interpregnancy intervals in Uganda

The mean interpregnancy interval was 28 months. About 31% of the mothers had an interpregnancy interval of less than 24 months and 10.6% of the mothers had an interval less than 18 months. Mothers above 35 years of age, of high parity, of secondary education level, and mothers whose preceding child was still alive had longer mean birth intervals. Short intervals were more common among mothers of the Nyole tribe, and those who breastfed for less than one year (Appendix 1: Table 1). Of the mothers whose children died, 80% became pregnant after the death of the child.

Table 2: Appendix 1, shows that factors strongly associated with short interpregnancy intervals were adverse pregnancy outcome, previous child death, and short lactation periods. Distal determinants strongly associated with short intervals were adolescent pregnancy and high parity. Low maternal education was not significantly associated with short interpregnancy intervals.

We explored the association between the distal determinants and lactation and adverse pregnancy outcome. Uneducated mothers, and mothers of the Nyole tribe were more likely to have short lactation periods. Uneducated mothers, low domestic animal score, and young maternal age, was associated with child mortality.

Another cut-off point for very short intervals was used to determine risk factors associated with very short interpregnancy intervals. Table 5 shows risk factors associated with very short intervals of less than 18 months. Adverse pregnancy outcome in the previous pregnancy and high parity were strongly associated with short interpregnancy intervals. Mothers who had not started attending antenatal care in the index pregnancy were more likely to have very short intervals. The low domestic animal score was still associated with short intervals (OR 1.5, 95% CI: 0.9-2.7) but this was not statistically significant in the multivariate analysis.
Table 5. The association of selected maternal characteristics (expressed as an odds ratio (OR and 95% Confidence interval (CI)) and short interpregnancy intervals less than 18 months in Bunyole (n= 2408).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Short interpregnancy Interval</th>
<th>Univariate analysis</th>
<th>Full model</th>
<th>Reduced Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>&lt;18</td>
<td>%</td>
<td>OR</td>
</tr>
<tr>
<td>Previous pregnancy outcome</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>alive</td>
<td>2032</td>
<td>98</td>
<td>4.8</td>
<td>1</td>
</tr>
<tr>
<td>born alive and died</td>
<td>248</td>
<td>72</td>
<td>29.0</td>
<td>8.1</td>
</tr>
<tr>
<td>adverse pregnancy outcome</td>
<td>120</td>
<td>84</td>
<td>70.0</td>
<td>46.0</td>
</tr>
<tr>
<td>Current maternal age (in years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;19yrs</td>
<td>248</td>
<td>50</td>
<td>20.2</td>
<td>2.7</td>
</tr>
<tr>
<td>20-24</td>
<td>825</td>
<td>85</td>
<td>10.3</td>
<td>1.2</td>
</tr>
<tr>
<td>25-29</td>
<td>694</td>
<td>60</td>
<td>8.6</td>
<td>1</td>
</tr>
<tr>
<td>30-34</td>
<td>376</td>
<td>36</td>
<td>9.6</td>
<td>1.1</td>
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<tr>
<td>35-39</td>
<td>265</td>
<td>25</td>
<td>9.4</td>
<td>1.1</td>
</tr>
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<td>Parity</td>
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<td>2-3</td>
<td>819</td>
<td>90</td>
<td>11.0</td>
<td>1</td>
</tr>
<tr>
<td>4-5</td>
<td>732</td>
<td>75</td>
<td>10.2</td>
<td>0.9</td>
</tr>
<tr>
<td>6 or more</td>
<td>857</td>
<td>91</td>
<td>10.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Gestational age at first attendance</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>1-6 months</td>
<td>718</td>
<td>72</td>
<td>10.0</td>
<td>1</td>
</tr>
<tr>
<td>7-9 months</td>
<td>853</td>
<td>80</td>
<td>9.4</td>
<td>0.9</td>
</tr>
<tr>
<td>not started yet</td>
<td>794</td>
<td>100</td>
<td>12.6</td>
<td>1.3</td>
</tr>
<tr>
<td>Maternal education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>none</td>
<td>808</td>
<td>91</td>
<td>11.3</td>
<td>1.5</td>
</tr>
<tr>
<td>primary 1-4</td>
<td>637</td>
<td>68</td>
<td>10.7</td>
<td>1.4</td>
</tr>
<tr>
<td>primary 5-7</td>
<td>769</td>
<td>82</td>
<td>10.7</td>
<td>1.4</td>
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<tr>
<td>secondary</td>
<td>174</td>
<td>14</td>
<td>8.0</td>
<td>1</td>
</tr>
<tr>
<td>Marital status</td>
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<td></td>
</tr>
<tr>
<td>married monogamous</td>
<td>1626</td>
<td>187</td>
<td>11.5</td>
<td>1</td>
</tr>
<tr>
<td>married polygamous</td>
<td>744</td>
<td>64</td>
<td>8.6</td>
<td>0.7</td>
</tr>
<tr>
<td>single</td>
<td>38</td>
<td>5</td>
<td>13.2</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Pearson chi2(263) =250.53  p= 0.6996
Hosmer-Lemeshow chi2(8) =3.83  p= 0.8718
5.2. **Short interpregnancy intervals in Denmark**

The median interpregnancy interval was 37 months and only 4.8% of mothers had an interval less than 9 months. Mothers with short intervals were slightly older (mean 26.5 ± 3.7 years) than mothers with longer intervals (mean 25.0 ±4.5 years). Other than women aged 35-49, first parity mothers had consistently shorter intervals within their age groups (Appendix 2: Table 1).

Table 3, Appendix 2, shows that the statistically significant risk factors associated with short intervals were unplanned pregnancy, high parity, being unemployed, and living in a flat. There was a significant trend in increasing risk for short birth intervals with increasing maternal age, maternal smoking (Appendix 2: Figure 2).

Table 6 shows a broad overview of the results of the two studies. For comparative purposes, Ugandan data presented consider interpregnancy intervals less than 18 months, which is comparable to a 9-month birth-to-conception interval used in the Danish dataset. Younger mothers in Uganda were more likely to have short intervals while older mothers in Denmark were more likely to have short intervals. While there is a significant inverse relationship between maternal education and short interpregnancy intervals in Denmark, this is not evident from the Ugandan data. Poor social status is associated with short interpregnancy intervals in both countries.
Table 6. Overall description and summary of key results for both studies from Denmark and Uganda.

<table>
<thead>
<tr>
<th>Study Characteristics</th>
<th>Denmark</th>
<th>Uganda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of study</td>
<td>Population based cohort with register linkage</td>
<td>Population based cohort study</td>
</tr>
<tr>
<td>Study period</td>
<td>1984-1987</td>
<td>1999</td>
</tr>
<tr>
<td>Study base</td>
<td>All pregnant women in Odense and Aalborg (n=11850)</td>
<td>All pregnant women in Bunyole at given time (n= 3708)</td>
</tr>
<tr>
<td>Sampled population</td>
<td>85 % of all pregnant women in the study area</td>
<td>75% pregnant women</td>
</tr>
<tr>
<td>Eligible respondents</td>
<td>5709</td>
<td>2623</td>
</tr>
<tr>
<td>Sample used in analysis</td>
<td>2904</td>
<td>2408</td>
</tr>
<tr>
<td>Outcome variable</td>
<td>Preceding interpregnancy interval &lt;9 months</td>
<td>Preceding interpregnancy interval &lt;18 month</td>
</tr>
<tr>
<td>Proportion of mothers with birth interval &lt;9 months</td>
<td>4.8%</td>
<td>10.6%</td>
</tr>
<tr>
<td>Median interpregnancy interval</td>
<td>37 months</td>
<td>27 months</td>
</tr>
<tr>
<td>Mean maternal age</td>
<td>26.5(s.d. 3.7)</td>
<td>25.1 (s.d. 6.5)</td>
</tr>
<tr>
<td>High Parity &gt;3</td>
<td>4.3%</td>
<td>66%</td>
</tr>
</tbody>
</table>

Risk factors associated with short interpregnancy intervals

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>OR</th>
<th>95% CI</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous pregnancy outcome</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abortion and stillbirth</td>
<td>50.3</td>
<td>31.3 – 80.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child dead at time of interview</td>
<td>8.1</td>
<td>5.7- 11.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short lactation periods (mothers with children alive)</td>
<td>1.7</td>
<td>1.1-2.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Menstrual irregularity</td>
<td>1.7</td>
<td>1.1-2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unplanned pregnancy</td>
<td>2.9</td>
<td>2.2-3.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High parity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal age &lt;25</td>
<td>0.7</td>
<td>0.4-1.3</td>
<td>2.3</td>
<td>1.5-3.4</td>
</tr>
<tr>
<td>Maternal age 31-49</td>
<td>1.7</td>
<td>1.1-3.1</td>
<td>0.7</td>
<td>0.6-1.0</td>
</tr>
<tr>
<td>Low/no maternal education</td>
<td>1.2</td>
<td>0.8-1.9</td>
<td>1.0</td>
<td>0.7-1.5</td>
</tr>
<tr>
<td>Heavy smoking</td>
<td>1.6</td>
<td>1.0 -2.5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Living in flat</td>
<td>1.7</td>
<td>1.1-2.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amenity score</td>
<td>0.9</td>
<td>0.6-1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic animal score</td>
<td>1.9</td>
<td>0.7-4.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.3. Child mortality in Uganda

Using the preceding birth technique, the child mortality rate was estimated at 108 per 1000 live births. Approximately 93% of child mortality occurred before the age of two. The estimated annual under-two child mortality rate was 82 per 1000 child years of risk (Appendix 3: Table 2). Deaths were three times more likely to occur in the neonatal period than in the post neonatal period. Risk factors associated with increased risk for child mortality were no maternal education, young maternal age, and mothers above 35.

Uganda experienced increased and prolonged rains caused by the El Niño Southern Oscillation weather pattern in 1997 and 1998. There was a seasonal correlation of child death, which closely followed the El Niño weather pattern (Appendix 3: Figure1). There was a one-month time lag between high monthly rainfall and child mortality. A high proportion of child deaths also followed the unusual peak rainfall in November and December 1997. Although there were few recorded deaths in 1997 (n=47), Table 7 presents results of parametric and non-parametric tests for seasonal variation and shows that the peak child mortality occurs between June and August both in both 1997 and 1998. This corresponds to the dry season that occurs immediately after the peak rainy season in Tororo.

Mortality levels were different at parish level. Figure 8 shows higher mortality occurring in parishes that had the lowest population density, and those in the Southwest of the county.
**Table 7.** Results of parametric and non-parametric tests for seasonal variation of child mortality among in children born alive in Bunyole, Uganda.

<table>
<thead>
<tr>
<th>Months</th>
<th>1997</th>
<th>1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>February</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>March</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>April</td>
<td>1</td>
<td>27</td>
</tr>
<tr>
<td>May</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>June</td>
<td>8</td>
<td>19</td>
</tr>
<tr>
<td>July</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>August</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>September</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>October</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>November</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>December</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>47</td>
<td>216</td>
</tr>
</tbody>
</table>

**Tests for seasonal variation**

<table>
<thead>
<tr>
<th>Test</th>
<th>Peak Months</th>
<th>p</th>
<th>Peak Months</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edward’s test</td>
<td>August</td>
<td>0.05*</td>
<td>August</td>
<td>0.001</td>
</tr>
<tr>
<td>Freedman’s test deviation from uniform incidence</td>
<td>&lt; 0.05</td>
<td></td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Hewitt’s rank-sum test: 4 month peak</td>
<td>May-August</td>
<td>&gt; 0.09</td>
<td>June-September</td>
<td>&gt;0.09</td>
</tr>
<tr>
<td>Hewitt’s rank-sum test: 6 month peak</td>
<td>May-October</td>
<td>&gt; 0.13</td>
<td>April-September</td>
<td>0.03</td>
</tr>
</tbody>
</table>

*Conservative p values (n<50)
Figure 8. Map of study area showing mortality and population density differences in Bunyole.
6. Discussion

6.1. Main results

In Uganda, interpregnancy intervals, less than 24 months, occurred among one third of the mothers. Very short intervals, less than 18 months, occurred in 10.6% of the sampled population. Risk factors associated with short interpregnancy intervals were adverse pregnancy outcomes, previous child death, short lactation periods, young maternal age, and low social status. Maternal education was not associated with short interpregnancy intervals. The under-2 child mortality is still high and may be considered an important cause of short interpregnancy intervals.

Child replacement is probably the most important determinant of short intervals in this community. The findings that 80% of mothers whose children died became pregnant after the death of the child, and that mothers whose children died after one year of age were more likely to have longer intervals than mothers with living children, imply that child replacement may be the most important determinant of short intervals in this rural population.

In the Danish cohort, only 4.8% of the mothers had short birth-to-conception interval of less than nine months, which is comparable to an 18-month interpregnancy interval if the subsequent delivery is a full term delivery. Short interpregnancy intervals were more likely to occur among mothers who did not plan their pregnancy, mothers with irregular menstruation, and in older mothers. Low social status, living in a flat, poor education and heavy smoking were all significant social factors associated with short interpregnancy interval.

6.2. Source of bias

6.2.1. Selection bias

In the Ugandan study, approximately 75% of the households in the geographical area were visited and 19% of all women were pregnant at the time of the visit. This is similar to the estimated prevalence of pregnant women in a given time in a developing country.\textsuperscript{114} Previous pregnancy outcomes, age, and education of the eligible mothers not interviewed were similar to the study participants. Withdrawals and loss to follow-up was reduced because mothers were actively identified at their homes by the local teams. By December 1999, only 58 mothers who were lost to follow-up had either divorced or migrated from the study area. Crude estimates for previous pregnancy outcome, maternal education, and social status score for mothers interviewed were similar to estimates obtained with 2408 mothers, who had all data available included in the multivariable analysis.

By selecting only pregnant mothers, we excluded mothers that may have had long intervals because they are subfecund or are using a postpartum contraceptive method.
Although this would seem to overrepresent mothers with short intervals, the prevalence of short intervals between live births in this study was similar to the 1995 Demographic and Health Survey which includes both pregnant and non-pregnant respondents. We therefore believe that selection bias was minimised in this study and the results are largely representative for this population.

In the Danish cohort information was obtained from 87% of all eligible women in a well-defined geographical area. For less than 6% of the mothers information could not be linked to the CPR register and these were excluded from the analysis. We restricted our analysis to mothers with interpregnancy intervals less than 37 months. This was done because information was collected at the time of the second birth of the pair and the longer the interval, the higher the probability that the social determinants under study may have changed. This also reduces the bias introduced by other factors that potentially modify and increase interpregnancy intervals such as subfecundity and postpartum contraceptive use.

6.2.2. Information bias

In the Ugandan study, the reporting age, birth dates, and pregnancy outcomes are subject to recall bias. In maternity history data collection, mothers may not accurately report the dates of birth of the preceding child or other pregnancy outcomes. This was minimised by asking about the recently ended pregnancy and the current pregnancy, and by training interviewers to specifically ask about abortion and stillbirths. Furthermore, sensitivity analysis showed minor differences in the risk estimates for previous pregnancy outcome, maternal age and parity. The respondents’ age structure was similar to that in the DHS study.

Lactation data were imprecise and showed digital preference for 12, 18, and 24 months. Self-reported lactation periods are usually overestimated, given that mothers may want to tell you what you would like to hear. This may lead to non-differential misclassification of lactation patterns. However, this information was adequate for this study, given that we dichotomised lactation to a short period less than 12 months, and long periods. Analysis of the lactation patterns was restricted to mothers with living children, since mothers stop breastfeeding when their children die.

Two limitations of the study were that information on pregnancy planning was not collected, and data on use of contraception before the current pregnancy were not used. Pregnant women are not expected to give you accurate information about planning of the current pregnancy and the data would thus be subject to recall bias. Information on contraceptive use before index pregnancy suggests that 7% of mothers used a method of contraception. However, withdrawal, abstinence, and barrier methods were the most commonly used methods, which are not very effective.

A common problem that exists in many studies is the inability to distinguish the temporal relationship between child mortality and short birth intervals. By subtracting 280 days or 9 months from the date of birth, we estimated the conception date and compared this date to the date of death of the preceding child. This study
shows that short intervals usually occur after the death of the previous child.

In the Danish dataset, information on contraceptive use, breastfeeding patterns, and spontaneous or induced abortion was not collected. Mothers with spontaneous abortion or induced abortion are more likely to be erroneously classified as having long intervals.

6.2.3. Confounding
Stratified analysis indicated that the association between parity and short interpregnancy interval was confounded by age in both datasets. This is expected given that fecundity is affected by age and parity. Lactation pattern analyses were restricted to mothers with living children. In the Ugandan data set, estimates from univariate analysis and the full models show that the association between previous pregnancy outcome and short interpregnancy intervals is not confounded by social factors studied.

In the Danish dataset, although stratified analysis among identified risk factor groups did not show confounding among the groups, crude and adjusted risk estimates in the final multivariate model indicates some confounding from the social risk factors.

6.3. Main findings compared to other studies

6.3.1. Prevalence of short birth intervals
The prevalence of short interpregnancy intervals in this study is comparable to other studies in sub-Saharan Africa. A more recent review of DHS data from 20 countries shows that on average, 17% of birth intervals are less than 24 months, and this prevalence varies from 9% to 27%. Birth interval trend analysis shows that birth intervals have been increasing over time but this increase is small in Uganda, about 2 months from 1970s to 1990s.

The DHS data also includes information on mothers preferred birth intervals. Although there are many limitations in measurement of preferred birth intervals from DHS data, it has been shown that most women in many countries prefer to have longer intervals than the actual interval they had. If the women’s preferred birth intervals prevailed, the prevalence of interpregnancy intervals less than two years would decline from the average 17% to 11%. On average, this decrease would translate into a 7% decrease in child mortality. From the point of view of the potential reduction in neonatal and infant mortality, the prevalence of short interpregnancy intervals should be reduced.

Prevalence studies from developed countries are difficult to compare with developing countries given that the different cut-off points are used, when studying different adverse pregnancy outcomes. This emphasises that there lacks a definition of an "optimum interval" below which adverse pregnancy outcomes may occur. One reason is that the definition of this "optimum" interval is "population-specific". What is clear however, is that most interpregnancy intervals below 12 months are associated
with an increased risk of adverse pregnancy outcomes. Different populations need to determine a birth interval below which adverse pregnancy outcomes are most likely to occur.

### 6.3.2. Determinants of short birth intervals

**Child mortality and adverse pregnancy outcome**

Previous child loss and adverse pregnancy outcome are strongly associated with short interpregnancy intervals. It is usually difficult to sort out the direction of causation between pregnancy intervals and infant mortality. Efforts have been made to determine whether increased fertility after child mortality is merely a replacement effect or whether additional parental concern may lead to extra insurance births. Child replacement strategy has been observed in Senegal and some of the results of this study are consistent with the child replacement strategy.

**Lactation**

The greater fertility following child mortality has both biological-lactational and behavioural components and the relative balance probably depends on the local situational determinants. This relationship is difficult to determine when you consider that lactation is not purely biological since its duration is itself behaviourally determined. Early child death would remove the protective effect of lactation. Lactation durations are behaviourally determined as mothers may opt to breastfeed for shorter periods. This leads to fertility differences amongst populations. The fact that 30% of mothers with living children breastfed for less than a year, and Nyole mothers were more likely to have short breastfeeding patterns implies that lactation is behaviourally determined in this population.

**Maternal age and parity**

The association between maternal age and parity in the Ugandan study is consistent with other studies that show young mothers in developing countries are more likely to have short interpregnancy intervals. It has been shown that recovery of ovarian function was faster among young mothers than older mothers and may be an important determinant of short birth intervals among young mothers. However, in Denmark, where the mean age at first birth is 26.1 years, older mothers were more likely to have a shorter interval so that they can quickly complete their family size. Thus, changing the maternal age at first birth will change the age risk profile of mothers having short interpregnancy intervals.

**Socio-economic risk factors**

The observed relationship between maternal education and fertility is not uniform amongst developing countries. Most studies show that low maternal education is significantly associated with short intervals, while other studies show no relationship with maternal education and short birth intervals. Comparative studies show that maternal education in Uganda is not associated with short interpregnancy intervals. This study shows that low maternal education is not associated with an
increased risk of short interpregnancy intervals.

Studies from both developing and developed countries consistently show the association between low social status and short interpregnancy intervals. Social status indicators are difficult to define in developing countries. In an anthropological study in a predominantly pastoral society in Kenya, livestock wealth was correlated with reproductive success, measured by the number of children. This reproductive success may be a result of early marriages and polygamy practiced by the wealthier respondents. Although short interpregnancy intervals were not associated with short birth intervals, mothers in polygamous union were more likely to be of high parity and to have a high domestic animal score than those in monogamous marriages. Of the two socio-economic scores used in the present study, low domestic animal score is consistently associated with an increased risk of short interpregnancy intervals. This relationship between the two SES scores and short intervals seem to act in different proximate determinants. Low animal score seems to act through reduced child survival while the low amenity score seems to act through short lactation periods.

6.3.3. Determinants of child mortality

Study findings on determinants of child mortality in Uganda are consistent with earlier studies on child mortality. The study also shows the importance of parental literacy, especially husband education, and is consistent with other studies that have considered husband education as a risk factor independent of SES.

The preceding technique has been used in community and antenatal settings and is a robust method that can be used by health management teams to monitor child mortality trends. A study on the effects of length of birth interval on infant and child mortality, concluded that short preceding birth intervals are associated with a 58% higher risk of dying before the age of 5 years, while long birth intervals are associated with a 28% lower risk of dying, compared with intervals 24 to 27 months in length.

The seasonal patterns of child mortality with El Niño weather phenomenon is consistent with other studies that show seasonal differences in morbidity and mortality in other areas of the country.
7. Conclusions

The results of these studies on short interpregnancy intervals show that in this rural Ugandan population, child replacement is probably the predominant strategy used by mothers. Short lactation patterns seen in this community are also an important proximate determinant of short interpregnancy interval. Interventions for improving obstetric outcome and child survival would reduce the occurrence of short interpregnancy intervals.

In Denmark, strong predictors for short interpregnancy intervals are mainly biological - menstrual irregularity and unplanned pregnancy. Thus most short intervals are unplanned and women, especially toward the end of their reproductive career may consciously choose to have short intervals.

Although the level of maternal education is not strongly associated with short interpregnancy interval, it is strongly associated with child mortality. Maternal education may indirectly lengthen birth intervals interpregnancy through improving child survival, postponing the age at first birth, and increasing contraceptive use.

Regardless of the definition of social status, both studies show that low social status is strongly associated with short intervals; this implies that short interpregnancy interval is indeed a marker of women who may have a poor reproductive outcome.

The preceding births technique offers an opportunity to study mortality trends in the age group usually targeted for child survival programmes. It would also give information for planning health service delivery at community level.
8. Perspectives

One of the fundamental and important population policy guidelines is that individuals and couples should be enabled to realise their reproductive intentions and preferences, that is, to have the number and spacing of children that they desire. Given the emphasis on promotion of family planning for purposes of birth spacing, the results of this research are directly relevant to public health and population policy for it is useful to know the characteristics of mothers with short interpregnancy intervals or who prefer short interpregnancy intervals. It has been shown that fertility preferences differ among different communities.131 Although education seems to have a role to play in most countries, it seems to have a limited role in Uganda. It is therefore important to determine other factors that mask the effect of maternal education on short interpregnancy intervals.

Assessing birth intervals allows one to generate information about intentional birth spacing, rates of adverse pregnancy outcome, and information that helps identify patterns of high-risk maternal groups. The preceding birth technique is robust and flexible tool for this purpose. It can be applied to routinely collected information during antenatal sessions or during community surveys that interview reproductive age women such as nutrition surveys or immunisation surveys. Assessing birth intervals should be introduced as an indicator for fertility and mortality trend research. Using the preceding birth technique in routine data collection allows optimum use of routine data collected rather than waiting for expensive cross-sectional surveys to determine trends in child mortality.
9. Summary

Background

Short interpregnancy intervals still constitute a major reproductive health problem in both developed and developing countries. The distribution of, reasons for, and effects of short interpregnancy intervals vary considerably amongst populations. Given the large variation of risk factors associated with short interpregnancy intervals, it is important to know and compare the specific factors that determine, and outcomes that follow short interpregnancy intervals in any given population. The present studies aimed at identifying key determinants of short interpregnancy intervals among women from two populations and beyond short interpregnancy intervals, identify other determinants of child mortality in rural Uganda.

This thesis is based on three papers and a brief communication on two population-base cohorts; one from Uganda and another from Denmark.

Methods

The Ugandan study was carried out in two phases. An initial cross-sectional house-to-house survey identified and interviewed all women in a geographically defined rural area in Eastern Uganda pregnant at the time of the survey. The follow-up phase was carried out with 2635 eligible pregnant women who were interviewed during pregnancy, to determine maternal risk factors for short interpregnancy intervals, and soon after delivery for information on delivery and pregnancy outcome.

In Denmark, determinants of short interpregnancy intervals were studied, in an existing dataset, from a cohort of 2904 mothers with interpregnancy intervals less than 37 months. These mothers were identified from a population-based cohort study from a geographically two defined areas, Odense and Aalborg.

Results

In Uganda, 31.0% of mothers had short interpregnancy intervals less than 24 months and 10.6 % mothers had intervals less than 18 months. Adverse pregnancy outcomes (spontaneous abortion and stillbirth), previous child mortality and short lactation periods were strongly associated with short interpregnancy intervals. Being a young mother, or of high parity, or of low social economic status was associated with an increased risk of having short interpregnancy intervals less than 24 months. Maternal education was not associated with short interpregnancy intervals.

The preceding birth technique was used to estimate mortality rate among 2888 children born alive. The under-2 mortality rate was 108 per 1000 live births. Mothers under 25 or above 35 years of age, and couples with no formal education were more likely to have lost the preceding child. Child mortality was strongly correlated with prevalent weather patterns.

In Denmark, 4.8% of the mothers had a short birth-to-conception interval interpregnancy interval less than 9 months. Older mothers, mothers of low social
status, and low education, and those with irregular menstruation or those who had planned their pregnancies were more likely to have short interpregnancy intervals

**Conclusion**

Child replacement plays an important role in determining short birth intervals in rural Uganda while short intervals are by choice among women in Denmark. Regardless of the definition of social status, both studies show that low social status is associated with short interpregnancy intervals. Biological factors, such as irregular menstruation, play a significant role in determining very short interpregnancy intervals.

The preceding births technique offers an opportunity to study trends in child mortality in the under-2, an age group that is usually targeted for child survival programmes.
10. Danske Resumé

Baggrund
Kort afstand mellem to fødsler er et sundhedsproblem for børn og mødre, som forekommer både i industrialiserede lande og i udviklingslande. Hyppigheden af årsagerne til konsekvenserne af kort afstand mellem to fødsler varierer fra land til land. Da disse variationer kan skyldes, at der er forskellige risikofaktorer, der er dominerer i det enkelte land, kan en kortlægning og sammenligning af forskellige landes risikomønster give viden, der kan anvendes til at bedre børns og mødres sundhed.

Formålet med det aktuelle studie er, i to forskellige populationer, at identificere nogle centrale determinanter for kort afstand mellem fødslerne, samt at identificere andre risikofaktorer, der ud over kort interval mellem fødslerne, er af betydning for børnedødelighed i et landdistrikt i Uganda.

PhD-afhandlingen består af en oversigt samt fire videnskabelige artikler som alle bygger på data fra to populationsbaserede kohorteundersøgelser fra henholdsvis Uganda og Danmark.

Metode
I Uganda blev de kvinder, der indgik i studiet, kontaktet to gange. I det indledende survey blev alle gravide i et geografisk afgrænset område spurgt om en række risikofaktorer, og i et follow-up, der foregik efter fødslen, blev de samme 2.635 kvinder spurgt om fødselsens forløb og om barnets tilstand.

I studiet i Danmark indgik 2.904 kvinder, som havde født to børn inden for en periode af 37 måneder. Undersøgelsen baseredes på tidligere indsamlede data fra to kohortestudier fra henholdsvis Odense og Aalborg.

Resultater
Inden for en periode på 24 måneder havde 31% af kvinderne i kohorten fra Uganda født to børn og 10,6% havde født to gange inden for 18 måneder. Kortvarigt ammeforløb, dødsfald af et nyfødt barn samt et utilisitet forløb af graviditeten (f.eks. spontan abort, dødsfødsel) var tæt associeret med kort afstand mellem fødslerne. Andre risikofaktorer for kort interval mellem to fødsler var: ung alder, mange fødsler og lav social status. Varigheden af moderens skoleuddannelse var derimod ikke en risikofaktor.

De 2.888 mødre, der inden den aktuelle fødsel havde født et levende barn, indgik i et studie, hvor formålet var at estimere børnedødeligheden. Det viste sig at 10, 8% døde inden for de første to leveår. Øget risiko for død blev fundet blandt børn af foreldre uden uddannelse og blandt børn, hvis mødre var under 25 eller over 35 år. Børnedødelighed varierede en del hen over året, og svingningerne viste sig at være tæt korreleret til klimaet, idet dødeligheden var højest én måned efter regntiden.
I Danmark blev 4,8% af mødrene gravide igen, inden der var gået 9 måneder efter fødslen. Lav social status, kort uddannelse, uregelmæssige menstruationer, og planlagt graviditet var faktorer, der alle var associeret til kort afstand mellem graviditeterne, desuden havde også ældre kvinder en øget risiko for at blive gravid to gange inden for så kort en periode.

**Konklusion**

I landdistrikterne i Uganda tydede risikofaktorerne på, at et kort interval mellem fødslerne var udløst af et ønske om at erstatte tabet af det forrige barn, medens det i Danmark så ud til, at de, der fik to børn hurtigt efter hinanden, bevidst valgte dette. Uanset hvordan social status blev defineret, så var lav social status i begge lande associeret med kort afstand mellem to fødsler. I Danmark spillede en biologisk faktor som uregelmæssige menstruationer også en signifikant rolle, for at kvinder hurtigt blev gravide igen.

I udviklingslande bliver dødeligheden inden for de første to leveår hyppigt anvendt som monitoreringsmål i børneprogrammer. Dette dødelighedsmål kan man estimere ved i surveys at spørge om forløbet af den forrige graviditet.
11. References


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Appendices

Paper I  Social determinants of short interpregnancy intervals in rural Uganda

Paper II: Choice and chance: Determinants of short interpregnancy intervals in Denmark

Paper III Child mortality in rural Uganda

Accompanying letter: A simple birth interval calculator

Abstract [Separate page]