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The Existence and Determinants of Sex Differentials in Infant and Early Child Mortality in the Sahel

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During the past two decades, considerable research has been conducted on the existence and determinants of sex differentials in mortality in less developed countries. Much of this work has focused on the Indian subcontinent, where excess female child mortality has been linked to discrimination within families in the provision of nutrition and health care. The underlying causes of this discrimination have been argued to be the relatively greater economic value of sons to their families of birth in the medium and long terms, low levels of female autonomy, and prevailing cultural and religious attitudes that place more value on sons.[1]

This subject has received little attention in Subsaharan Africa, where the relative mortality risk faced by female children appears to be both high by European standards and low by Indian or Bangladeshi standards. Gbenyon and Locoh (1989) and Mandjale (1985) examined the geography of sex mortality differentials in Africa; while they found evidence of excess female mortality in certain areas south of the Sahara, they were unable to discern a clear pattern to the differentials. For the Sahel, several studies have documented excess female post-neonatal and/or child mortality in both Mali and Senegal.[2]

In this paper, three small-area longitudinal data sets for the cities of Bamako (Mali), Bobo-Dioulasso (Burkina Faso), and for a rural area in Senegal are used to study the existence and possible causes of sex differentials in post-neonatal and early child mortality. The next section summarizes the results of previous research on the determinants of excess female child mortality and develops the hypotheses to be tested. Data and the methodology used in the empirical study are then described, and are followed by the results of the analysis. The final section is a discussion of the findings.

Review of Previous Findings

On the whole, girls are believed to be innately more resistant to health risks than boys.[3] Excess female child mortality, where it exists, is likely to be caused by one of three things: (1) girls' particular vulnerability to a specific health risk (or set of health risks) that is a major cause of death in the area, (2) discrimination within families in the provision of health care or nutrition, and (3) socioeconomic and cultural variables which underlie the family's desire and ability to treat their sons and daughters

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[1] See, *e.g.*, Koenig and D'Souza (1985), Koenig and Wojtyniak (1987), D'Souza and Chen (1980), Chen *et al.* (1981), Amin and Pebley (1987), Das Gupta (1987), Basu (1989), Khan *et al.* (1989), Rosenzweig and Schultz (1982), and Bardhan (1984), chapter 15.

[2] Mbacké and LeGrand (1991), Mbacké (1989b), Fargues and Nassour (1988), Cantrelle *et al.* (1986), and Barbieri (1989).

[3] Preston (1976) and Waldron (1983 & 1987).

differently.

Biological Causes of Death

The importance of different causes of death varies by age. Mortality during the first few weeks of life is in large part attributable to congenital deformities and injuries occurring at birth that disproportionately affect male infants.[4] The infectious and parasitical diseases of diarrhea, malaria, measles and respiratory diseases are the most important causes of death in the Sahel for children aged one month and above. The incidence of these diseases appears to be similar for both sexes, although girls seem to have a small, innate advantage in surviving most of them, especially during infancy.[5] Moreover, in spite of boys' generally higher birthweights, their lungs are on the average less fully developed. This leads to greater male vulnerability to respiratory diseases that is strongest during the first few months of life.[6] Finally, at all ages male death rates from accidents and other violence are higher than those of females across the world; Preston (1976) argues that, to some extent, this may be due to boys being less able to recover from injuries than girls.

Several studies have shown girls to be at greater risk of dying from measles. Cantrelle *et al.* (1986) found that girls aged under 5 were significantly more likely to die of measles than boys in rural Senegal.[7] They also cite World Health Organization statistics showing that, throughout the developing world, girls aged 1 to 4 are more likely to die from measles and/or a larger percentage of their deaths are due to this disease. Fargues and Nassour (1988) state that the excess mortality of girls aged 1 to 4 in Bamako between 1975 and 1985 can be attributed to their greater risk of dying from measles. Aaby *et al.* (1986), in a study of data on children aged 6 to 36 months in Guinea-Bissau, found that secondary cases of measles in a household (*i.e.*, children who are infected by another household member) are at greater risk than the index (first) case. Moreover, girls who are infected by a brother were found to be at the greatest risk of death. Thus, they argue, it is possible that mortality risk

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[4] See Waldron (1983) and (1987).

[5] Waldron (1983); see also Basu (1989), Chen *et al.* (1981), Koenig and D'Souza (1985), Black *et al.* (1982), Bhuiya (1983), and Aaby *et al.* (1984).

[6] Waldron (1983). Concerning the Sahel, Cantrelle *et al.* (1986) found that male children were more likely to die of respiratory disease than were girls in the Ngayokhème area of rural Senegal, an area located near the EMIS study area.

[7] Stephens (1984) also found higher female measles mortality in rural Senegal.

from measles may be relatively higher for girls in situations where the disease is introduced into the household by a brother.

There are three possible explanations for the high relative risk of girls dying from measles. First, girls may simply be genetically more susceptible to the disease. This hypothesis is not supported by research by Aaby *et al.* (1986), who showed that measles case fatality rates by sex are equal for index cases. Second, discrimination in nutrition or health care may render girls especially vulnerable to the disease.[8] Cantrelle *et al.* (1986) and Aaby *et al.* (1986), however, found no evidence of differential treatment of boys and girls in the areas that they studied. In addition, if pervasive discrimination against girls is the cause of sex differentials in measles mortality risk, it is puzzling that its effects are not also observed for other causes of death. Finally, gender differences in social roles and interactions may alter the measles exposure patterns by sex.[9] However, it is unlikely that social interactions greatly differ by sex for infants and toddlers, the age groups under study here.

In this study, EMIS data will be used to verify whether excess female mortality is associated with a comparatively high percentage of female deaths to measles. The possible link between respiratory disease and high relative male mortality will also be examined.

Discrimination in Nutrition and Health Care

In West Africa, evidence on sex discrimination in nutrition is inconclusive. As noted above, Cantrelle *et al.* (1986) and Aaby *et al.* (1986) did not find evidence of discrimination in rural Senegal and Guinea-Bissau. Barbieri (1989) reports that DHS data for Senegal show boys being more likely to receive bottled milk than girls. She also found that, while the mean age of weaning is similar for both sexes, its variance is smaller for boys. Further, boys' nutritional status (measured by anthropometric indicators) is somewhat worse between 20 and 30 months, the age range during which they are most likely to be weaned. Garenne *et al.* (1987) found girls to be slightly better off in terms of anthropometric measurements in a rural area of Senegal. Mbacké and LeGrand (1991) did not find any significant sex differences in nutritional status in a study of Malian DHS data. Guèye (1987:178), using EMIS data for Bobo-Dioulasso, reported that growth faltering starts earlier and is more severe for male infants and toddlers. Trussell *et al.* (1989) note

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[8] Phillips et al. (1987), for example, argue that this may be the reason why measles vaccinations had a significantly greater impact on female child mortality rates relative to that of boys in the Matlab Thana of rural Bangladesh.

[9] Aaby *et al.* (1984) and (1986), Bonneuil and Fargues (1989), and Cantrelle *et al.* (1986).

that some women interviewed for the same survey reported that sons suckled more vigorously than daughters and hence received more breastmilk. They also found amenorrhoea to be shorter after the births of daughters than sons.

Deaton (1988), in a study of World Bank Côte d'Ivoire Living Standards Survey data, did not find evidence of differential treatment of boys and girls within households either in terms of total expenditures or expenditures on food. Sahn (1990) analyzed anthropometric data collected by this survey and reported male children in urban areas significantly more likely to be chronically malnourished (height for age). However, concerning current malnutrition (weight for height) and in rural areas in general, there were no significant differences between the sexes. Aldeman (1990), studying similar data from Ghana, found female children to be insignificantly better off in terms of anthropometric measures of nutritional status.

It should be stressed that boys' favored status within households, to the extent that it exists, does not necessarily translate into better nutritional status and then onto relatively lower male mortality risk. Families may not be aware of the nutritional value of foods; Barbieri (1989), for instance, notes that boys in Senegal may be "favored" with more bottled milk, which is less healthful than breastmilk. Poor nutritional status, as measured by anthropometric indices, can reflect the effects of prior or ongoing illnesses rather than inadequate nutrition *per se*. There is, moreover, increasing evidence that mild and moderate levels of malnutrition do not greatly increase a person's risk of death.[10]

Concerning health care, the results of the few studies examining discrimination by sex are also mixed. Again, research by Cantrelle *et al*. (1986) on Senegal found no evidence of discrimination in health care favoring boys or girls. In contrast, Locoh (1986) reports that boys in Lomé are more likely to be hospitalized when in need than girls, and Fargues and Nassour (1988) note similar findings for Bamako. Mbacké and LeGrand (1991) found that Malian boys were more likely to be taken to a health center for treatment for diarrhea and fevers, and to have received multiple inoculations for poliomyelitis and the disease set of diphtheria, tetanus and pertussis. Barbieri (1989) reports that Senegalese boys are more likely to receive some form of treatment for malaria or diarrhea, although type of treatment and overall vaccination rates are similar for both sexes.

The presumed link between excess female mortality and differential treatment of girls and boys in terms of vaccinations, medical health care, and breastfeeding will be tested in the empirical section.

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[10] Behrman *et al*. (1988).

The Ultimate Socioeconomic and Cultural Causes of Death

A widespread perception is that parents would prefer to have more boys than girls in most West African societies. To date, little has been published on sex preference attitudes in the region. Barbieri (1989) found that, given the choice, Senegalese parents would typically prefer to have either the same number of boys and girls or just one more boy than girls. Locoh (1986), while noting that parents would typically prefer the first child to be male, found no difference in sex preferences for subsequent children among women in Togo. Overall, the picture is one of boys being somewhat more desired than girls, but where differences in gender preferences for economic, cultural or other reasons are much less pronounced than those documented for South Asia.

<u>Income and earnings potential</u> Which socioeconomic or cultural factors underlie the decisions of parents to discriminate in their treatment of boys and girls? An argument made for India and Bangladesh is that boys are of greater value than girls as productive assets to their families.[11] Social norms and possibly differences in physical strength constrain women's work activities outside the home, and home production is perceived as having less value than other work. In this situation, the perceived long-term economic value of boys exceeds that of girls, leading to a bias in the distribution of household resources. Discrimination against girls will tend to be greater in situations where family resource constraints are tight and, therefore, equal treatment of children is viewed as a luxury, affordable only after a certain level of economic security is attained. EMIS data will be used to test the validity of this higher income-lower relative female mortality risk hypothesis in the Sahalian context.

In contrast to the microeconomic arguments presented above, an anthropological model developed by Dickemann (1979) hypothesizes that in poor and especially in polygamous societies, female infanticide and differential neglect of daughters will occur primarily among the higher socioeconomic strata. In essence, she argues that male children of the upper classes are likely to acquire, when adult, a disproportionately large number of spouses and, therefore, their expected "reproductive success" (number of progeniture) and their long-term value to their families are greater than that of female siblings. In contrast, for poorer families a daughter's expected reproductive success and her value exceeds that of her brothers. In such a situation, parents will tend to discriminate and perhaps seek to eliminate the less valued children in the family--girls in the upper classes and more rarely boys in the lower classes.

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[11] See, *e.g.*, Rosenzweig and Schultz (1982) and Bardham (1984).

Rising incomes may affect levels of relative mortality risk by sex for a variety of other reasons. First, greater family resources increase the potential scope of favored treatment given to more valued children and thus may increase sex mortality differentials.[12] Diminishing returns to expenditures on health and nutrition can cause a fall in relative female mortality risk, even in situations where the degree of household discrimination in resource allocation remains unchanged. Finally, higher incomes may be associated with a declining importance of infectious and parasitic diseases, for which the inherent female advantage is less strong, acting disproportionately to reduce female mortality.

Evidence on the relationship between household resources and mortality risk by sex is inconclusive. D'Souza *et al.* (1988) and Behrman and Kenen (1985) found discrimination against girls to be more pronounced during the 1974-75 famine in Bangladesh and during the lean season in India, respectively. A large number of other studies have instead found either no effect or a positive effect of household income or wealth on the relative female mortality risk; see Muhuri and Preston (1991) for a partial review. Rutstein (1984), in a comparative analysis of WFS data, showed that the mortality risk of girls relative to boys tends to decrease as the overall mortality risk of infants and, to a lesser extent, of children aged 1-4 falls. This relationship could be caused by a number of factors including that of rising incomes tied to economic development. However, a study of 20 African countries by Gbenyon and Locoh (1989) did not reveal evidence of such a differential mortality-level of mortality relationship.

Locoh (1986) and Gbenyon and Locoh (1989) point out that women's economic value to their families is generally large in Subsaharan Africa. Girls tend to be heavily involved in economic activities from an early age, bride prices are more typical than dowries, a woman's ability to aid her parents is considerable, and women's autonomy in many domains is often large. While it remains true that women's social and legal statuses are often inferior to those of men, the economic rationale for discrimination by parents against girls is much less strong in Subsaharan Africa than in South Asia.

Mother's education Caldwell (1979) has argued that mothers develop especially close attachments to their children, and are hence more concerned with their children's welfare regardless of sex. As women's educational attainment increases and their decision-making power in the family improves, the allocation of household resources to children should increase and discrimination against girls should decrease, leading to a decline in relative female mortality risk.

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[12] Das Gupta (1987).

To our knowledge, the analysis of EMIS data will be the first empirical test of this hypothesis in Africa. In South Asia, contradictory results abound: mother's education was found to be related to lower female relative risks of death in India (Bourne and Walker, 1991, and Caldwell *et al.*, 1983), higher relative risks in Bangladesh (Huda, 1980, and Bhuiya and Streatfield, 1991) and in the Punjab (Das Gupta, 1987), and roughly equal relative risks in India (Basu and Basu, 1991), Bangladesh (Muhuri and Preston, 1991), and Pakistan (Sathar, 1991). For Brazil, Thomas (1989) reports that mother's income - also a measure of a woman's power in the household - has a greater impact on child health than does father's income. Moreover, mothers were seen to favor girls, and fathers boys, in the allocation of their income.

<u>The sex composition of older siblings</u> The sex composition of surviving older siblings in the family is hypothesized to affect the mortality risk of the child in question. According to this argument, boys and girls are not perfect substitutes in terms of their productive and perhaps consumption value--the pleasure that they give their parents. The first son and daughter are highly prized by their parents; however, as the number of surviving sons or daughters grows, the relative importance placed on the next son or daughter, respectively, falls, and the likelihood of their facing discrimination in the allocation of household resources increases.

The relationship between "wantedness" and the number of older siblings of the same sex can systematically differ for boys and girls. Das Gupta (1987) found that Punjabi girls are particularly disadvantaged when they have at least one older sister. Muhuri and Preston (1991) similarly documented a very strong, positive relationship between female child mortality risk and the number of surviving older sisters for a rural area of Bangladesh. They also reported a much weaker relationship between male child mortality and surviving brothers. Stanton and Clemens (1986), in a study of urban Bangladesh, instead found that the increase in mortality risk linked to the number of older siblings of the same sex was roughly equal for boys and girls.

The EMIS do not contain information on the sex composition of older surviving children. However, if the degree of discrimination increases with the number of older siblings of the same sex, and the effect is considerably more pronounced for girls than for boys, then an excess female mortality-birth order link should be apparent. This is the third hypothesis concerning ultimate determinants to be investigated.

<u>Urban/rural residence</u> Community-level factors determine the degree to which son preference can be readily translated into excess female mortality. Gbenyon and Locoh (1989) found evidence of higher relative female mortality risks in African urban areas, despite the presence of generally higher levels of income and wealth. They argue that the presence of more extensive, curative medical facilities in

urban areas increases the scope of possible discrimination in favor of boys, and that the high cost of these services occasions a more explicit choice within the household of who receives quality health care. In isolated rural areas, the possibility of providing such quality of care to a child is not an option. They conclude that the relative prices of health care options in an area are a critical determinant of relative mortality risks. By comparing results for rural Senegal and the cities of Bamako and Bobo-Dioulasso, EMIS data can indicate whether excess female mortality is more pronounced in urban areas.

Other researchers believe that the male advantage is generally greater in rural areas. Preston (1976), citing evidence from several studies, argues that men's economic comparative advantage is larger in heavy agricultural work and that this work may, in fact, be directly beneficial to their health. In the African context, it is increasingly difficult for urban parents to monitor and acquire a sizable proportion of son's earnings with the monetarization of economies. Daughters are, instead, more likely to work in the family environment, where shirking is less feasible, and their importance as caregivers for the elderly is undiminished.[13] For these reasons, it is possible that the relative worth of sons to their families is lower in urban areas.

<u>Cultural norms and religious doctrines</u> Culturally-based attitudes and religious doctrines may also lead to more importance being placed on male children and/or dictate different ways of treating boys and girls. It has been argued that Islamic doctrines defining women's roles and activities may underlie discrimination against daughters. While several studies have documented excess female child mortality in North African and Middle Eastern countries, Gbenyon and Locoh (1989) showed that the geographic pattern of sex differentials in mortality in Subsaharan Africa is not closely linked to the Islamic religion.[14] The diversity of cultures and norms in West Africa makes it difficult to generalize about their influence on sex differentials in mortality risk. With EMIS data, the estimated effects of ethnicity can provide an indication of the importance of cultural and perhaps religious factors on sex mortality risks.

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[13] Dieudonné Ouedraogo, personal communication.

[14] Cantrelle *et al.* (1986) also did not find an effect of religion on children's survival propensity in Senegal. Studies showing excess female mortality in North Africa include Mandjale (1985), Suchindran and Adlakha (1985), Tabutin (1990) and Vallin (1983).

Parents' perception of health risks for sons and daughters A last explanation for different treatment of sons and daughters is made by Locoh (1986) and Trussell *et al.* (1989), who note that parents may discriminate in health care and nutrition even in the absence of sex preferences or cultural norms, if they perceive boys and girls to have different needs or to be differentially vulnerable to diseases. This possibility cannot be studied with EMIS data.

Data and Methodological Approach

The data used in the analysis are from three EMIS[15] surveys for the cities of Bamako (Mali), Bobo-Dioulasso (Burkina Faso) and for the rural "arrondissements" of Fissel and Thiénaba in the region of Thiès, Senegal. The EMIS are prospective surveys, containing data collected between 1981 and 1985 under the aegis of the Institut du Sahel in collaboration with national agencies. They are based on a survey methodology developed at IFORD for use in the *Enquête sur la Mortalité Infantile et Juvénile* surveys.

Data were first collected at the time of birth for a cohort of children born over a year period to resident mothers. These children were then visited 7 times over the following 2 year period, at ages: 1 month, 4 months, and thereafter every 4 months. An effort was made to include all births occurring during the year in the Bobo-Dioulasso EMIS. For Bamako, hospital and clinic births - the large majority of all births in the city - were surveyed for 3 days out of 5, and a small proportion of home births were also captured. For the rural area in Senegal, all children were first surveyed shortly after the birth, based on a prior census of pregnant women in the area and on information from village-level informants. The EMISs collected detailed information on a wide variety of subjects, including child health care and weaning practices, mortality and cause of death, housing characteristics, parents' educational attainment and ethnic affiliation.

There are positive and negative aspects to the longitudinal nature of the data. An important advantage is that differential misreporting of deaths by sex, a risk for retrospective surveys when parental sex preferences exist, is not an issue. Age at death and several other variables of interest are also more accurately measured by longitudinal surveys.

[15] *Enquête sur la Mortalité Infantile dans le Sahel* or, in English, survey on infant mortality in the Sahel.

The main disadvantage of EMIS data is their being unrepresentative of the general population, a condition that is aggravated by sample selectivity over the 7 interview period.[16] Concerning the initial sample, births outside of maternity clinics and hospitals in Bobo-Dioulasso and, particularly, in Bamako are greatly underenumerated. Insofar as these births occur disproportionately to relatively impoverished and traditional women, the sample systematically differs from the total population of births. There is also evidence that a number of births in hospitals and clinics were missed, and that a relatively large proportion of these ended in the death of the child at or shortly after birth.[17]

Next, there is the problem of children being lost from observation during the subsequent passages. This progressive sample selectivity is most pronounced for the first passage following birth, when many newborns could not be located from addresses recorded at clinics and hospitals. Again, children of the lower classes, who tend to live in the crowded and unzoned areas of the city, are more likely to be lost from observation, systematically altering the composition of the data set. These sample selectivity problems are less severe for EMIS-Senegal, where essentially all births were recorded, and only a small proportion were lost from observation during the two year period.

The potential effect of sample selectivity from losses from observation on sex mortality differentials is unclear. In an effort to assess its importance, a multivariate logit regression was used to impute the probability of dying between 1 and 23 months, based on a broad set of demographic, socioeconomic and ethnic characteristics of children observed to survive or die. The average risk of death by sex was then estimated for the entire data set (including those lost from observation) and again for the subset of children observed to survive or die. Finally, these were used to compute female-to-male mortality ratios for both the total and "observed" populations. These ratios were nearly identical for all areas, never differing by more than 0.004.

These results suggest that sample selectivity, at least after the neonatal period, will not substantially bias the results. While it remains true that selectivity biases related to unobserved characteristics may systematically alter the mortality risks by sex, there is no prior, theoretical reason to believe that they do. Only sex-specific child fosterage practices may have an important impact on both the probabilities of mortality and loss from observation, an impact that should be small for children under 2 years of age.

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[16] For details on EMIS data problems, see van de Walle (1986), Nassour and van de Walle (1987), Mbacké (1986 and 1989a), Fargues (1985), Guèye (1987), Houehougbe (1985) and IFORD (1985).

[17] Van de Walle (1986).

In order to limit the possible effects of sample selectivity, the analysis is restricted to the 1-23 month age span.[18] In the regression analysis, a discrete hazard logit model is used to reduce potential sample selectivity biases due to losses from observation. For the same reason, in all simple tabulations the survival of children is weighted by the proportion of the period during which they are under observation. For example, a child who is observed to survive up to month 20 and is then lost from observation will be counted as surviving the toddler (12 to 23 month) age span with a weight of 0.667 (or 8/12ths). Unless otherwise indicated, all statistical tests are two-tailed tests.

Table 1 presents the total number of children and their status at age 2 for each of the EMIS data sets used in the analysis. Only children who survived the neonatal period and are under observation for at least two consecutive passages are included in this data.

Table 1. Status of Children at Age 2

	Bamako	Bobo-D.	Senegal	Total
Total children	9,491	7,217	4,696	21,404
Survived under observation	6,896	5,825	3,974	16,695
Observed death	629	565	584	1,778
Post-neonatal death	408	341	303	1,052
Toddler death	221	224	281	726
Lost from observation	1,966	827	138	2,931

Empirical Analysis

In this section, areas and age groups for which excess female or male mortality is apparent are first distinguished. Three possible determinants for these differences are then studied: differential vulnerability to specific causes of death, discriminatory health and feeding practices, and socioeconomic and ethnic factors.

The Existence of Sex Differentials in Mortality

Table 2 contains estimates of total mortality probabilities and the female to male relative risk of death by month of age for the three EMIS data sets. The age pattern of relative mortality risks by sex is similar for Bamako and Bobo-Dioulasso. During the first

[18] In any case, neonatal deaths are dominated by endogenous causes, for which female infants are at an advantage. For all 3 data sets, the estimated risk of death for female neonates is considerably less than that of males.

half-year life, boys face a greater risk of death. In both cities, month 6 stands out as a turning point in relative risks, with girls experiencing higher levels of mortality for between the months 6 and 15. For children aged 16-23 months, the patterns become less distinct, with no clear tendency of excess mortality risk by sex.

Table 2. Mortality Probabilities and the Sex Mortality Ratio by Age

EMIS: Month of Age	Bamako Mortality Prob. Total	Bamako Mortality Prob. fem/male	Bobo-Dioulasso Mortality Prob. Total	Bobo-Dioulasso Mortality Prob. fem/male	Senegal Mortality Prob. Total	Senegal Mortality Prob. fem/male
1	6.053	84.1	6.021	73.4	6.132	140.7
2	3.248	79.9	2.478	481.9	3.191	149.2
3	3.666	65.3	4.554	55.3	7.257	126.2
4	2.271	93.5	2.855	64.3	3.898	200.0
5	4.010	87.4	2.433	40.2	2.826	160.4
6	4.243	147.6	4.161	118.4	5.232	71.7
7	4.478	119.1	4.035	173.3	7.451	161.9
8	4.832	101.7	4.045	103.9	6.892	183.8
9	4.971	88.5	5.715	86.8	7.164	89.5
10	4.414	125.6	6.957	114.7	8.117	72.4
11	3.266	117.5	6.549	110.9	8.411	132.8
12	3.771	109.7	2.513	123.6	4.845	76.0
13	2.807	94.3	3.307	105.8	7.883	144.7
14	3.917	171.4	3.475	115.4	5.609	60.9
15	2.457	191.3	3.963	171.1	6.345	147.3
16	3.010	45.0	2.789	107.7	4.756	101.6
17	2.363	161.2	2.303	95.7	5.972	79.8
18	2.237	56.0	3.791	41.9	5.047	111.5
19	1.318	11.4	3.639	114.5	5.072	92.2
20	1.652	203.0	2.518	192.8	5.137	92.4
21	1.517	58.1	2.524	144.9	3.688	116.2
22	1.796	45.1	3.879	88.7	5.922	61.0
23	1.937	56.3	2.878	138.1	6.950	87.9

Note: Mortality probabilities are per 1000, female-to-male mortality ratios are per 100 and age is in completed months.

The age-sex pattern of relative risks is strikingly different for rural Senegal. Female infants are seen to face considerably higher mortality risks for the 1-5 months age span, a period when boys are generally believed to face much greater risks. Further, the fact that excess female mortality for this age group is only evident in rural Senegal contradicts the hypothesis that female relative mortality risks should be more pronounced in urban areas. A turning point again occurs at or slightly after month 6, with no strong pattern of relative risks by sex apparent for older children.

Table 3 presents estimated mortality probabilities by sex for post-neonates, toddlers (12-23 months), the full 1-23 month age span, and for the three other age groups that appear to most emphasize sex differentials in Table 2: 1-5 months, 6-15 months and 16-23 months. Statistics are presented for each of the EMIS areas separately and for the pooled urban areas of Bamako and Bobo-Dioulasso.[19]

The post-neonatal, toddler and 1-23 month age groups tend to average together mortality probabilities from ages of excess female mortality risk with those from ages of equal or excess male risk, reducing the observed importance of sex differentials. For these age groups, the only significant difference in mortality risk is found for Senegal, where post-neonatal girls experience higher mortality at the 10% level of significance.

Sex differentials in mortality risk are more apparent for the new age breakdowns. For children aged 1-5 months, male infants in the combined urban areas and female infants in Senegal face higher mortality risks that are significant at the 5% level.[20] Female children aged 6-15 months experience relatively higher mortality in all three study areas; this excess risk is significant at the 5% level in the combined urban areas and at the 10% level in the city of Bamako alone. Finally, male children aged 16-23 months in Bamako are found to face significantly higher mortality risks, while in Bobo-Dioulasso and Senegal their sex mortality differentials are insignificant.

Determinants of Sex Differentials in Mortality

For the rest of this study, the causes of sex differences in mortality are examined for six age groups: post-neonatal, toddler, 1-23 months, 1-5 months, 6-15 months and 16-23 months. To the extent that mortality differentials by sex exist, they appear to be emphasized by the three non-standard age groupings, and the use of these age groups may highlight the effects of possible determinants.

<u>Biological Causes of Death</u> Table 4 presents the percentages of female and male deaths from five cause of death categories: (1) measles, (2) respiratory illnesses, (3) diarrhea, stomach illnesses

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[19] Bamako and Bobo-Dioulasso are both moderate-to-large cities in a region of similar climatic conditions that display similar patterns of total and relative mortality risks by sex.

[20] Note that significance levels presented here will slightly overestimate the true levels for age groups 1-5, 6-15 and 16-23 months. The reason for this is that these age groups were chosen to maximize differences in mortality risks by sex, and thus the estimated statistics are *conditional* on these earlier observations.

Table 3. Mortality Probabilities by Sex and Age Group

Age group: Post-neonatal	- - - Mortality - - - Male	Female	fem/male	Diff f-m	Signif of dif
Bamako	48.72	47.62	97.74	-1.10	
Bobo-Dioulasso	53.34	51.82	97.14	-1.52	
Bamako & Bobo	50.69	49.47	97.60	-1.22	
Senegal	58.65	72.01	122.79	13.37	**

Age group: 12-23 months	- - - Mortality - - - Male	Female	fem/male	Diff f-m	Signif of dif
Bamako	33.61	30.86	91.82	-2.75	
Bobo-Dioulasso	36.41	40.21	110.44	3.80	
Bamako & Bobo	34.88	35.23	101.01	0.35	
Senegal	67.63	64.42	95.26	-3.21	

Age group: 1-23 months	- - - Mortality - - - Male	Female	fem/male	Diff f-m	Signif of dif
Bamako	90.23	85.73	95.02	-4.50	
Bobo-Dioulasso	92.94	95.16	102.38	2.22	
Bamako & Bobo	91.45	90.10	98.52	-1.35	
Senegal	123.25	133.01	107.92	9.77	

Age group: 1-5 months	- - - Mortality - - - Male	Female	fem/male	Diff f-m	Signif of dif
Bamako	23.22	18.70	80.55	-4.52	*
Bobo-Dioulasso	22.14	17.29	78.10	-4.85	*
Bamako & Bobo	22.76	18.09	79.46	-4.68	***
Senegal	18.87	27.86	147.66	8.99	***

Age group: 6-15 months	- - - Mortality - - - Male	Female	fem/male	Diff f-m	Signif of dif
Bamako	38.30	45.91	119.84	7.60	**
Bobo-Dioulasso	43.52	49.75	114.31	6.23	
Bamako & Bobo	40.59	47.65	117.40	7.06	***
Senegal	63.60	69.55	109.35	5.95	

Age group: 16-23 months	- - - Mortality - - - Male	Female	fem/male	Diff f-m	Signif of dif
Bamako	20.63	13.59	65.90	-7.03	***
Bobo-Dioulasso	23.97	24.66	102.89	0.69	
Bamako & Bobo	22.14	18.76	84.73	-3.38	*
Senegal	44.46	39.86	89.67	-4.59	

Notes: Mortality probabilities are per 1000 and "fem/male" is the female mortality probability divided by the male probability per 100. The 2 columns at the right are the difference between female and male mortality probabilities and its significance level: *=20%, **=10%, and ***=5%.

and malnutrition, (4) malaria and fevers, and (5) other, unknown or poorly defined causes of death. If differential mortality by sex is due to the effects a specific cause, it should be evident from the percentage distribution of deaths in the table. If, instead, it results from a general increase in mortality risk for all causes of death, then the distribution by sex will be the same.

EMIS cause of death data is of uneven quality. Cause of death is declared by the mother and, while some clearly identifiable and well known diseases such as measles should be accurately reported, many others will not. In addition, the cause of death categories used in this study are aggregations of more detailed classifications which vary from one EMIS to the next. While every effort was made to create coherent disease groups, the data remain inconsistent to some degree. Finally, a single "other" category, accounting for between 8% and 41% of recorded deaths of different age, sex, and area groups, includes all deaths that could not be assigned to one of the major disease categories.

Previous studies have shown girls to be more vulnerable to measles and boys to respiratory diseases. Measles accounts for 11.2% of female deaths and 11.0% of male deaths for children aged 1-23 months recorded by the combined EMIS data sets.[21] Differences between the proportions only reach the 20% level of significance in the city of Bobo-Dioulasso, where the proportion of female deaths from measles is higher for children aged 6-15 and lower for children aged 16-23 months. When data from Bamako and Bobo-Dioulasso are pooled, the male percentage of deaths to measles is higher at the 10% level of significance for the 16-23 month age group.

Concerning respiratory diseases, 9.7% of female and 8.1% of male deaths for children aged 1-23 months in the three areas are attributed to this cause. The difference between the percentages of female and male deaths is significant only at the 20% level for the age group 6-15 months in Senegal, where the percentage of female deaths is almost twice that of males.

The diarrhea category is the most important reported cause of death in each of the EMIS areas. For children aged 1-23 months, diarrhea accounted for 37.2% of female and 39.4% of male deaths. Differences between male and female percentage deaths attributed to this cause are never significant, in any area or for any age group. Malaria and fevers are the declared cause 18.7% of female and 17.8% of male deaths in the three areas. Sex differences in the percentage dying from these diseases are rarely significant even at the 20% level. The only exception concerns children aged 12-23 in Bamako, for whom the proportion of male deaths is significantly higher at

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[21] The small percentage of deaths from measles was in part caused by the lack of a measles epidemic in Bamako for most of the study period.

Table 4: Percentage of Male and Female Deaths by Reported Biological Cause

Age group: Post-neonatal

EMIS: Cause of Death	Bamako % Deaths Male	Bamako % Deaths Female	Bamako Diff f-m	Bamako Sig	Bobo-Dioulasso % Deaths Male	Bobo-Dioulasso % Deaths Female	Bobo-Dioulasso Diff f-m	Bobo-Dioulasso Sig	Senegal % Deaths Male	Senegal % Deaths Female	Senegal Diff f-m	Senegal Sig
Measles	2.4%	2.0%	-0.38%		24.9%	31.0%	6.14%		8.1%	6.0%	-2.10%	
Respiratory	11.0%	12.1%	1.06%		8.9%	11.1%	2.24%		11.8%	12.0%	0.21%	
Diarrhea	35.9%	31.7%	-4.23%		31.9%	28.6%	-3.30%		33.8%	31.7%	-2.09%	
Malaria	16.8%	18.1%	1.34%		17.8%	13.5%	-4.30%		24.3%	28.1%	3.88%	
Other, ?	34.0%	36.2%	2.21%		16.6%	15.8%	-0.78%		22.1%	22.2%	0.10%	

Age group: 12 - 23 months (toddlers)

EMIS: Cause of Death	Bamako % Deaths Male	Bamako % Deaths Female	Bamako Diff f-m	Bamako Sig	Bobo-Dioulasso % Deaths Male	Bobo-Dioulasso % Deaths Female	Bobo-Dioulasso Diff f-m	Bobo-Dioulasso Sig	Senegal % Deaths Male	Senegal % Deaths Female	Senegal Diff f-m	Senegal Sig
Measles	9.5%	7.6%	-1.86%		5.8%	6.7%	0.95%		13.8%	14.0%	0.18%	
Respiratory	6.0%	8.6%	2.54%		2.9%	3.4%	0.48%		4.1%	8.8%	4.69%	*
Diarrhea	34.5%	35.2%	0.76%		61.5%	60.5%	-1.03%		47.6%	41.9%	-5.67%	
Malaria	18.1%	11.4%	-6.67%	*	14.4%	17.6%	3.22%		15.9%	21.3%	5.46%	
Other, ?	31.9%	37.1%	5.25%		15.4%	11.8%	-3.62%		18.6%	14.0%	-4.65%	

Age group: 1 - 23 months

EMIS: Cause of Death	Bamako % Deaths Male	Bamako % Deaths Female	Bamako Diff f-m	Bamako Sig	Bobo-Dioulasso % Deaths Male	Bobo-Dioulasso % Deaths Female	Bobo-Dioulasso Diff f-m	Bobo-Dioulasso Sig	Senegal % Deaths Male	Senegal % Deaths Female	Senegal Diff f-m	Senegal Sig
Measles	5.1%	3.9%	-1.26%		17.9%	20.6%	2.69%		11.0%	9.6%	-1.46%	
Respiratory	9.7%	10.7%	0.98%		6.5%	7.8%	1.32%		7.8%	10.6%	2.73%	
Diarrhea	34.7%	32.9%	-1.84%		43.4%	42.6%	-0.80%		40.9%	36.3%	-4.62%	
Malaria	17.2%	15.8%	-1.41%		16.5%	15.2%	-1.28%		19.9%	25.1%	5.15%	*
Other, ?	33.2%	36.8%	3.54%		15.8%	13.9%	-1.92%		20.3%	18.5%	-1.80%	

(continued)

Table 4: Percentage of Male and Female Deaths by Reported Biological Cause (continued)

Age group: 1 - 5 months

EMIS: Cause of Death	Bamako % Deaths Male	Bamako % Deaths Female	Bamako Diff f-m	Sig	Bobo-Dioulasso % Deaths Male	Bobo-Dioulasso % Deaths Female	Bobo-Dioulasso Diff f-m	Sig	Senegal % Deaths Male	Senegal % Deaths Female	Senegal Diff f-m	Sig
Measles	1.0%	1.2%	0.26%		8.3%	5.1%	-3.25%		2.3%	3.1%	0.80%	
Respiratory	12.5%	12.2%	-0.30%		9.7%	11.9%	2.14%		22.7%	18.5%	-4.27%	
Diarrhea	31.7%	30.5%	-1.24%		33.3%	32.2%	-1.13%		29.5%	26.1%	-3.39%	
Malaria	18.3%	19.5%	1.24%		22.2%	20.3%	-1.88%		13.6%	21.5%	7.90%	
Other, ?	36.5%	36.6%	0.05%		26.4%	30.5%	4.12%		31.8%	30.8%	-1.05%	

Age group: 6 - 15 months

EMIS: Cause of Death	Bamako % Deaths Male	Bamako % Deaths Female	Bamako Diff f-m	Sig	Bobo-Dioulasso % Deaths Male	Bobo-Dioulasso % Deaths Female	Bobo-Dioulasso Diff f-m	Sig	Senegal % Deaths Male	Senegal % Deaths Female	Senegal Diff f-m	Sig
Measles	3.9%	3.9%	-0.02%		28.6%	35.9%	7.28%	*	11.8%	9.0%	-2.83%	
Respiratory	9.0%	10.4%	1.41%		8.3%	9.4%	1.16%		4.9%	9.0%	4.11%	*
Diarrhea	40.6%	34.6%	-6.03%		38.3%	34.6%	-3.75%		36.1%	34.6%	-1.50%	
Malaria	12.9%	15.4%	2.48%		12.8%	11.9%	-0.83%		27.8%	31.4%	3.63%	
Other, ?	33.5%	35.7%	2.17%		12.0%	8.2%	-3.85%		19.4%	16.0%	-3.42%	

Age group: 16 - 23 months

EMIS: Cause of Death	Bamako % Deaths Male	Bamako % Deaths Female	Bamako Diff f-m	Sig	Bobo-Dioulasso % Deaths Male	Bobo-Dioulasso % Deaths Female	Bobo-Dioulasso Diff f-m	Sig	Senegal % Deaths Male	Senegal % Deaths Female	Senegal Diff f-m	Sig
Measles	13.9%	8.7%	-5.19%		5.9%	1.4%	-4.49%	*	14.0%	15.9%	1.88%	
Respiratory	6.9%	8.7%	1.75%		0.0%	1.4%	1.39%		5.4%	7.3%	1.94%	
Diarrhea	26.4%	30.4%	4.05%		63.2%	65.3%	2.04%		53.8%	47.6%	-6.20%	
Malaria	25.0%	10.9%	-14.13%	***	17.6%	18.1%	0.41%		10.7%	15.8%	5.10%	
Other, ?	27.8%	41.3%	13.53%	*	13.2%	13.9%	0.65%		16.1%	13.4%	-2.71%	

Notes: Diarrheal deaths include those due to stomach illnesses and malnutrition, and malaria includes those attributed to fever. The "other" category includes unknown and multiple causes of death. The significance levels are: *=20%, **=10%, and ***=5%.

the 5% level. However, if all malaria deaths reported for this area and age group were excluded from calculations, the estimated difference between male and female mortality risks would diminish by only about two-fifths.

On the whole, these results indicate that differential vulnerability by sex to specific health risks is not the cause of observed sex differentials in mortality. The two prime contenders - measles and respiratory diseases - do not appear to differentially impact one or the other sex in general. To further investigate this issue, the seasonal distribution of male and female deaths by sex, age, and EMIS area was also examined (data not shown). Month of death is relatively well measured by the EMIS data sets and, given that diseases follow distinct seasonal patterns, the analysis provides a further opportunity to study sex differences in biological causes of death. The results did not reveal a clear seasonal pattern of mortality by sex in any of the areas. This finding reinforces the conclusion that vulnerability to specific diseases cannot explain the observed pattern of sex mortality differentials in the Sahel.

<u>Discrimination in Health Care and Nutrition</u> Vaccination status by age and type of curative health care given to a sick child prior to death are examined for the analysis of sex discrimination in health care. The EMIS surveys collected information on children's vaccination status for several diseases at each passage. There is some evidence of underenumeration of vaccinations; in particular, the percentage of Bamako children receiving the DPT vaccination for the disease set of diphtheria, pertussis and tetanus appears to be extremely low when compared to DPT+P vaccinations (including poliomyelitis) for other areas and to more recent DHS-Mali data. Children's vaccination status is based on mother's declarations at each survey passage. It is plausible that vaccinations are less likely to be reported when either they are not the result of the family's initiative (for example, those done during EPI-style vaccination campaigns or routinely at birth) and/or when they occurred well in the past (for example, tetanus inoculations during a prenatal visit). To the extent that vaccinations are under-enumerated by the EMISs, the results may be affected by misreporting biases.

Table 5 shows the probability of being vaccinated by sex, disease and EMIS study area, for children surviving under observation to age 24 months. These probabilities will tend to understate the true level of discrimination in the provision of health services insofar as disadvantaged children are more likely to die and be excluded from the calculations. Tuberculosis, measles and DPT+P vaccinations are reported on all EMIS data sets (DPT for Bamako), and meningitis and a separate polio vaccination are reported for Bamako. Age at vaccination was not recorded in the Senegalese data; for these children we only know if they were vaccinated by the end of survey coverage, usually at about 24 months of age.

Table 5. Percentage of Children Vaccinated by Age 2 among Those Who Survived under Observation, by Sex and Type of Vaccination.

EMIS:	Bamako		Bobo-Dioulasso		Senegal	
Vaccination	Male	Female	Male	Female	Male	Female
Tuberculosis	94.3	93.5	80.1	79.8	51.5	51.5
Measles	39.9	38.7	66.7	69.1	37.5	37.4
DPT+P	25.8	25.5	83.8	83.8	61.2	60.7
Polio	21.4	22.1	...	...	...	...
Meningitis	4.1	3.2	...	...	...	...

Note: A child is counted as having the DPT+T vaccination set if at least 1 inoculation occurred. Children in Senegal were also counted if they had been vaccinated for tetanus.

Differences in vaccination rates for boys and girls rarely exceed even 1%. In Bobo-Dioulasso, girls are slightly more likely to have been vaccinated against measles at ages 6 and 16 months (data not shown), the end points for the age interval during which the proportion of female deaths from measles exceeds that of males. For months 16 and 24, the probability of being vaccinated against measles is slightly higher for boys in Bamako and slightly lower for boys in Bobo-Dioulasso, areas and age groups for which the percentage of male deaths from measles is high.

Boys have a slight advantage in terms of the DPT+P vaccination, although differences are insignificant. For Bamako and Senegal, the EMIS also record the number of DPT+P vaccinations given to children. Multiple vaccinations, necessary for maximal protection, require a conscious effort on the part of the family and are thus probably less subject to misreporting errors. It is also possible that discrimination against girls will be more pronounced when greater parental attention and effort is needed. In both areas, boys were found to be more likely to receive 2 or more inoculations at the 20% level of significance. This result contrasts with the highly significant male advantage for multiple inoculations documented for urban Malian children with DHS data by Mbacké and LeGrand (1991).[22]

There is no evidence that discrimination in curative health care is an important cause of excess female mortality. Data from Senegal (the only EMIS containing such information) show that girls observed to die between the ages of 1-23 months are privileged in terms of modern medical care: 82.8% of girls received such care, in

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[22] Mbacké and LeGrand (1991) restricted their analysis to the small percentage of children in possession of a health book (*carnet de santé*) in which vaccinations are registered. These children are probably unrepresentative of the general population.

comparison with only 75.1% of boys.[23] This difference is significant at the 5% level. The proportion of girls receiving modern medical care exceeds that of boys for each of the age groups, including the 1-5 month group for which excess female mortality was documented.

Table 6 presents the percentage of children receiving supplemental foods (foods in addition to breastmilk) and weaned, by age in single months and by sex. Age at the introduction of supplemental foods is always very similar for boys and girls; for both sexes, the median age is 5 months for Senegal and 6 months for Bamako and Bobo-Dioulasso.[24] The median ages at weaning for boys and girls are also equal at 20 months for Bamako and Bobo-Dioulasso and 22 months for Senegal. The very small degree of variation in feeding behavior by age is not indicative of substantial discrimination by parents in their allocation of food between sons and daughters.

To conclude, the results do not support the hypothesis that excess female mortality is caused by substantial discrimination against girls in the provision of health care and nutrition. This finding must be qualified by recognizing the limitations of EMIS data. Detailed information on intensity of breastfeeding and type of modern medical care, for instance, was not collected. Also, as described above there are some problems of underreporting of vaccinations. That said, the general lack of evidence of major sex differences in a variety of feeding and health care practices suggests that such discrimination is unlikely to be a major cause of excess female mortality in the region.

<u>The Ultimate Determinants of Mortality Risks</u> A discrete hazard logit regression model is used to examine the effects of several socioeconomic, demographic and ethnic factors on sex mortality differentials. In this approach, a record is included in the regression each time that a child is observed alive at one passage and observed to have died or survived at the next.[25] Thus, a child who survives under constant observation for the full post-neonatal

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[23] Combined modern and traditional medical care is counted as modern care in this analysis.

[24] EMIS questionnaire and coding inconsistencies may underlie part of the estimated differences between study areas.

[25] For Bamako and Bobo-Dioulasso, the resulting data sets for the 1-23 month age span exceeded the computer's capacity of about 32,000 records. In these cases, the data sets were reduced in size by taking of a random sample of survivors - 60% for Bamako and 75% for Bobo-Dioulasso - and 100% "sample" of deaths. In the logit model, this sampling procedure biases only the constant term, which was subsequently adjusted to correct for it (Farewell (1979)).

Table 6. Percentage of Children Receiving Supplemental Foods or Weaned, by Age and Sex

	Supplemental Foods						Weaning					
	Bamako		Bobo-Dioulasso		Senegal		Bamako		Bobo-Dioulasso		Senegal	
Age	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1	20%	19%	1%	0%	10%	9%	0%	0%	0%	0%	0%	0%
2	23%	22%	2%	1%	15%	13%	0%	0%	0%	0%	0%	0%
3	27%	26%	6%	6%	34%	32%	0%	0%	0%	0%	0%	0%
4	33%	32%	20%	19%	41%	40%	1%	1%	0%	0%	0%	0%
5	40%	39%	27%	27%	51%	50%	1%	1%	0%	0%	0%	0%
6	58%	58%	72%	71%	75%	76%	1%	1%	1%	0%	0%	0%
7	71%	70%	85%	84%	92%	93%	1%	1%	1%	1%	0%	0%
8	82%	81%	97%	98%	94%	95%	2%	1%	1%	1%	1%	0%
9	88%	87%	98%	98%	96%	97%	2%	2%	1%	1%	1%	0%
10	92%	90%	99%	99%	98%	98%	3%	2%	2%	1%	1%	0%
11	94%	92%	99%	99%	99%	99%	4%	3%	2%	2%	1%	1%
12	98%	97%	100%	100%	99%	99%	6%	5%	4%	4%	1%	1%
13	98%	98%	100%	100%	99%	99%	7%	6%	5%	5%	1%	1%
14	99%	99%	100%	100%	99%	99%	11%	10%	8%	8%	2%	2%
15	99%	99%	100%	100%	99%	99%	14%	13%	11%	12%	3%	2%
16	99%	99%	100%	100%	100%	99%	19%	17%	17%	18%	4%	4%
17	100%	100%	100%	100%	100%	99%	24%	23%	23%	23%	8%	8%
18	100%	100%	100%	100%	100%	100%	39%	36%	33%	34%	17%	17%
19	100%	100%	100%	100%	100%	100%	47%	45%	44%	46%	22%	23%
20	100%	100%	100%	100%	100%	100%	54%	53%	55%	56%	31%	31%
21	100%	100%	100%	100%	100%	100%	59%	58%	62%	62%	49%	48%
22	100%	100%	100%	100%	100%	100%	67%	68%	71%	70%	66%	65%
23	100%	100%	100%	100%	100%	100%	75%	76%	80%	79%	76%	76%

Note: Age is in completed months. Due to differences in EMIS questionnaire and coding procedures, there are problems of data consistency across EMIS areas, especially for the first month.

period, covering four interview passages (months 1, 4, 8 and 12), will be counted as three separate observations, one for each of the three interpassage periods. Dummy variables for interpassage period are included in the regressions to control for varying baseline risk caused by changing ages and differing period lengths (3 or 4 months). To some extent, these variables will also control for the possible effects of sample selectivity due to losses from observation.

Survival status is regressed against a set of dummy variables for: sex and birth order of the child, mother's marital status, schooling and ethnic group, household socioeconomic status, the full set of sex interaction terms, and control variables for the interpassage periods. Definitions of variables and their means for the 1-23 month age group data set are found in Table 7. Socioeconomic status (SES) is measured by a three-level index calculated from housing information on floor, wall and ceiling materials, and electric lighting. EMIS-Senegal contains less detailed information on housing quality, causing problems of comparability. Given data lacuna and the general living conditions in rural areas, it was assumed that there were no cases of high SES in the Senegalese study area. Certain ethnic groups incorporate other closely related ethnicities: the Sarakole group includes the Soninke and Maraka, and the Poulaar includes the Peulh, Toucouleur and Djogorame. For Senegal, the bulk of other ethnicities are Wolof.

Tables 8 to 10 show the female-to-male mortality ratios by age group for children of specific characteristics, based on the regression results. In calculating these statistics, regression coefficients were used to compute the probability of dying for each interpassage period, from which mortality probabilities for the various age groups were derived. The "reference" probabilities refer to children with the modal characteristics: birth order 2-5, of monogamously married mothers with no schooling, residing in low quality housing (SES), and of Bambara (Bamako), Mossi (Bobo-Dioulasso) or Serrer (Senegal) ethnicity. These characteristics were then changed one-by-one to give the mortality probabilities displayed in the table. Two indicators of statistical significance are presented, the first for the difference between the estimated male and female mortality risks for children of otherwise identical characteristics (*i.e.*, whether the mortality ratio is significantly different from 1.0), and the second for the difference between a given sex mortality ratio and that for children with the reference characteristics.[26] The regression coefficients and asymptotic t-statistics are presented in the appendix.

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[26] This second statistic is simply the significance level of the appropriate sex interaction term in the regression.

Table 7. Definitions and Means for Exogenous Variables Used in Analysis of Children Aged 1-23 Months

Variable group		Categories	Bamako	Bobo-Dioulasso	Senegal
Sex		Male (R)	0.505	0.491	0.500
		Female	0.495	0.509	0.500
Birth order		1	0.187	0.201	0.123
		2-5 (R)	0.600	0.525	0.548
		6+	0.213	0.273	0.328
Household SES (from housing quality data)		Low (R)	0.626	0.654	0.739
		Medium	0.241	0.231	0.261
		High	0.133	0.115	n/a
Schooling of mother		None (R)	0.680	0.757	0.964
		Some	0.320	0.243	0.036
Marital status of mother		Unmarried	0.144	0.084	n/a
		Monogamous (R)	0.525	0.562	0.585
		Polygamous	0.331	0.353	0.415
Ethnicity of mother	*Bamako:*	Bambara (R)	0.347	n/a	n/a
		Malinke	0.158	n/a	n/a
		Sarakole	0.103	n/a	n/a
		Poular	0.139	n/a	n/a
	Bobo-Dioulasso:	Mossi (R)	n/a	0.259	n/a
		Bobo	n/a	0.187	n/a
		Dioula, Dafing	n/a	0.236	n/a
	Senegal:	Serrer (R)	n/a	n/a	0.662
		Other ethnic	0.254	0.318	0.338

Notes: Only records containing valid data for all variables above are included in the calculations. Means are calculated from the full data sets prior to sampling of survivors. (R) denotes the omitted reference categories in the regressions.

Table 8. Hazard Analysis of Sex Mortality Differentials: Bamako

Age Group:	Post-neonatal					Toddler: 12-23 months					1- 23 months				
	- - Mortality - -			Signif		- - Mortality - -			Signif		- - Mortality - -			Signif	
	Male	Female	f/m	f-m	▲f/m	Male	Female	f/m	f-m	▲f/m	Male	Female	f/m	f-m	▲f/m
Birth 1	6.88%	6.06%	0.881			1.93%	6.30%	3.259	***	***	8.55%	11.73%	1.371	*	
order 2-5	4.36%	4.25%	0.974		R	3.18%	4.12%	1.293		R	7.45%	8.00%	1.074		R
6+	3.78%	4.05%	1.070			3.56%	2.37%	0.665		**	7.06%	6.54%	0.927		
SES: Low	4.36%	4.25%	0.974		R	3.18%	4.12%	1.293		R	7.45%	8.00%	1.074		R
Middle	5.42%	3.29%	0.607	**	**	2.15%	2.81%	1.307			7.58%	6.00%	0.793		*
High	4.04%	2.06%	0.511	*	**	1.59%	3.06%	1.918			5.73%	4.65%	0.811		
Uneducated	4.36%	4.25%	0.974		R	3.18%	4.12%	1.293		R	7.45%	8.00%	1.074		R
Educated	3.39%	3.75%	1.105			2.11%	3.42%	1.622			5.47%	6.88%	1.257		
Unmarried	5.56%	5.30%	0.953			9.79%	3.08%	0.315	***	***	12.80%	8.25%	0.645	*	**
Monogamous	4.36%	4.25%	0.974		R	3.18%	4.12%	1.293		R	7.45%	8.00%	1.074		R
Polygamous	4.16%	5.10%	1.227			4.11%	3.12%	0.759		**	8.00%	8.12%	1.014		
Bambara	4.36%	4.25%	0.974		R	3.18%	4.12%	1.293		R	7.45%	8.00%	1.074		R
Malinke	3.79%	5.49%	1.449		*	2.86%	4.16%	1.455			6.57%	9.49%	1.444	*	
Sarakole	1.32%	2.76%	2.086	*	*	3.75%	6.05%	1.611			4.50%	7.70%	1.710	**	*
Poular	4.78%	4.92%	1.029			3.21%	2.36%	0.734			8.10%	7.41%	0.916		
Other eth	4.67%	4.49%	0.962			3.12%	3.49%	1.118			7.82%	7.80%	0.997		
Num obsn:	25358					20863					28007				
deaths:	382					213					595				

Age Group:	1-5 months					6-15 months					16-23 months				
	- - Mortality - -			Signif		- - Mortality - -			Signif		- - Mortality - -			Signif	
	Male	Female	f/m	f-m	▲f/m	Male	Female	f/m	f-m	▲f/m	Male	Female	f/m	f-m	▲f/m
Birth 1	3.20%	1.97%	0.616			4.29%	6.58%	1.532			1.35%	4.22%	3.119	**	***
order 2-5	2.52%	1.54%	0.611	*	R	3.07%	5.09%	1.660	***	R	1.93%	1.55%	0.799		R
6+	2.64%	2.22%	0.843			2.80%	3.06%	1.094		*	1.86%	1.19%	0.641		
SES: Low	2.52%	1.54%	0.611	*	R	3.07%	5.09%	1.660	***	R	1.93%	1.55%	0.799		R
Middle	3.21%	0.88%	0.275	***	***	2.92%	4.22%	1.445			1.51%	1.10%	0.727		
High	1.62%	0.95%	0.590			2.52%	3.02%	1.201			1.50%	0.68%	0.451		
Uneducated	2.52%	1.54%	0.611	*	R	3.07%	5.09%	1.660	***	R	1.93%	1.55%	0.799		R
Educated	2.97%	1.41%	0.476	**		1.64%	4.28%	2.617	***	*	1.30%	1.34%	1.032		
Unmarried	2.67%	2.33%	0.871			6.12%	5.13%	0.838		**	5.24%	1.03%	0.196	***	***
Monogamous	2.52%	1.54%	0.611	*	R	3.07%	5.09%	1.660	***	R	1.93%	1.55%	0.799		R
Polygamous	2.09%	1.58%	0.758			3.65%	5.24%	1.433	*		2.33%	1.55%	0.664		
Bambara	2.52%	1.54%	0.611	*	R	3.07%	5.09%	1.660	***	R	1.93%	1.55%	0.799		R
Malinke	1.90%	2.09%	1.100		*	2.90%	6.16%	2.122	***		1.87%	1.36%	0.731		
Sarakole	1.10%	1.09%	0.985			1.47%	5.25%	3.579	***	*	2.24%	1.59%	0.712		
Poular	2.13%	2.22%	1.046			4.37%	3.99%	0.915		*	1.53%	1.20%	0.783		
Other eth	1.50%	1.64%	1.089		*	4.29%	5.17%	1.206			2.34%	1.13%	0.485	*	
Num obsn:	17391					23688					13509				
deaths:	172					312					111				

Note: The 2-tailed test significance levels are: * = 20% (t-statistic = 1.282), ** = 10% (t = 1.645), and *** = 5% (t = 1.960). The first significance level shows if the sex mortality ratio is significantly different from 1.0 (equality), and the second if it is significantly different from that of the reference (R) child.

Table 9. Hazard Analysis of Sex Mortality Differentials: Bobo-Dioulasso

Age Group:	Post-neonatal					Toddler: 12-23 months					1-23 months				
	- - Mortality - -			Signif		- - Mortality - -			Signif		- - Mortality - -			Signif	
	Male	Female	f/m	f-m	▲f/m	Male	Female	f/m	f-m	▲f/m	Male	Female	f/m	f-m	▲f/m
Birth 1	7.42%	7.44%	1.002			5.83%	4.20%	0.720		*	12.46%	11.46%	0.920		
order 2-5	5.52%	5.34%	0.968		R	3.92%	4.61%	1.176		R	9.03%	9.88%	1.094		R
6+	2.71%	4.15%	1.533		*	3.04%	2.56%	0.841			5.45%	6.74%	1.236		
SES: low	5.52%	5.34%	0.968		R	3.92%	4.61%	1.176		R	9.03%	9.88%	1.094		R
middle	5.65%	5.81%	1.030			3.72%	2.70%	0.725		*	8.99%	8.47%	0.942		
high	2.64%	5.12%	1.939	*	**	1.24%	3.86%	3.124	**	*	3.79%	8.79%	2.323	***	***
Uneducated	5.52%	5.34%	0.968		R	3.92%	4.61%	1.176		R	9.03%	9.88%	1.094		R
Educated	5.50%	4.11%	0.747			3.41%	3.68%	1.078			8.68%	7.73%	0.890		
Unmarried	6.76%	6.92%	1.024			6.53%	4.64%	0.711			12.39%	11.67%	0.943		
Monogamous	5.52%	5.34%	0.968		R	3.92%	4.61%	1.176		R	9.03%	9.88%	1.094		R
Polygamous	7.96%	5.97%	0.749			4.83%	3.88%	0.803		*	12.27%	9.92%	0.808		**
Mossi	5.52%	5.34%	0.968		R	3.92%	4.61%	1.176		R	9.03%	9.88%	1.094		R
Bobo	4.64%	4.67%	1.007			3.27%	6.16%	1.885	**		7.63%	9.87%	1.294		
Dioula,Daf.	4.63%	4.73%	1.022			4.31%	7.24%	1.679	**		8.69%	10.91%	1.255		
Other eth	4.79%	4.27%	0.893			2.33%	5.23%	2.243	***	**	6.96%	8.99%	1.293	*	
Num obsn:		20,117					17,834					28,875			
Deaths:		338					224					562			

Age Group:	1-5 months					6-15 months					16-23 months				
	- - Mortality - -			Signif		- - Mortality - -			Signif		- - Mortality - -			Signif	
	Male	Female	f/m	f-m	▲f/m	Male	Female	f/m	f-m	▲f/m	Male	Female	f/m	f-m	▲f/m
Birth 1	3.45%	2.87%	0.832			5.52%	6.04%	1.093			4.38%	2.96%	0.676		
order 2-5	1.85%	1.85%	1.001		R	4.62%	5.07%	1.097		R	3.19%	3.25%	1.020		R
6+	1.11%	2.26%	2.035	*	*	2.55%	3.18%	1.247			2.09%	1.58%	0.753		
SES: low	1.85%	1.85%	1.001		R	4.62%	5.07%	1.097		R	3.19%	3.25%	1.020		R
middle	1.76%	1.93%	1.096			4.77%	4.64%	0.972			3.07%	2.04%	0.663		
high	0.84%	2.03%	2.419		*	1.98%	3.73%	1.886			1.10%	3.75%	3.411	*	**
Uneducated	1.85%	1.85%	1.001		R	4.62%	5.07%	1.097		R	3.19%	3.25%	1.020		R
Educated	1.73%	1.20%	0.696			4.38%	4.72%	1.077			3.04%	1.89%	0.621		
Unmarried	3.12%	3.44%	1.100			6.01%	5.62%	0.935			3.81%	2.32%	0.609		
Monogamous	1.85%	1.85%	1.001		R	4.62%	5.07%	1.097		R	3.19%	3.25%	1.020		R
Polygamous	2.72%	1.42%	0.521	*	*	6.69%	5.47%	0.818			3.58%	3.27%	0.914		
Mossi	1.85%	1.85%	1.001		R	4.62%	5.07%	1.097		R	3.19%	3.25%	1.020		R
Bobo	1.89%	1.14%	0.601			3.73%	5.30%	1.421			2.33%	4.60%	1.970	*	*
Dioula,Daf.	2.07%	1.80%	0.869			4.08%	5.40%	1.325			2.84%	4.42%	1.556		
Other eth	1.38%	1.31%	0.948			4.05%	5.30%	1.310			1.83%	2.60%	1.421		
Num obsn:		13,684					19,243					11,721			
Deaths:		131					290					141			

Note: The two-tailed test significance levels are: * = 20% (t-statistic = 1.282), ** = 10% (t = 1.645), and *** = 5% (t = 1.960). The first significance level shows if the sex mortality ratio is significantly different from 1.0 (equality), and the second if it is significantly different from that of the reference (R) child.

Table 10. Hazard Analysis of Sex Mortality Differentials: Senegal

Age Group:	Post-neonatal					Toddler: 12-23 months					1 - 23 months				
	- - Mortality - -			Signif		- - Mortality - -			Signif		- - Mortality - -			Signif	
	Male	Female	f/m	f-m	▲f/m	Male	Female	f/m	f-m	▲f/m	Male	Female	f/m	f-m	▲f/m
Birth 1	5.43%	6.93%	1.276			6.61%	9.14%	1.382			11.65%	15.19%	1.303		
order 2-5	5.36%	7.15%	1.335	*	R	8.29%	7.84%	0.946		R	13.14%	14.34%	1.091		R
6+	9.85%	9.53%	0.968		*	7.07%	8.42%	1.191			16.44%	17.26%	1.050		
SES: Low	5.36%	7.15%	1.335	*	R	8.29%	7.84%	0.946		R	13.14%	14.34%	1.091		R
Middle	3.33%	6.83%	2.051	***	*	6.03%	6.84%	1.134			8.93%	13.22%	1.480	**	*
High: n/a															
Uneducated	5.36%	7.15%	1.335	*	R	8.29%	7.84%	0.946		R	13.14%	14.34%	1.091		R
Educated	3.83%	9.96%	2.598	*		6.07%	9.51%	1.566			9.61%	18.59%	1.933	*	
Monogamous	5.36%	7.15%	1.335	*	R	8.29%	7.84%	0.946		R	13.14%	14.34%	1.091		R
Polygamous	6.86%	7.13%	1.038			8.23%	6.90%	0.839			14.76%	13.56%	0.919		
Unmarried: n/a															
Serrer	5.36%	7.15%	1.335	*	R	8.29%	7.84%	0.946		R	13.14%	14.34%	1.091		R
Other ethn	3.37%	5.16%	1.530	*		7.00%	4.19%	0.598	**	**	9.77%	9.22%	0.944		
Num obsn:	13,229					12,122					25,351				
Deaths:	296					271					567				

Age Group:	1 - 5 months					6 - 15 months					16 - 23 months				
	- - Mortality - -			Signif		- - Mortality - -			Signif		- - Mortality - -			Signif	
	Male	Female	f/m	f-m	▲f/m	Male	Female	f/m	f-m	▲f/m	Male	Female	f/m	f-m	▲f/m
Birth 1	1.97%	3.38%	1.715			4.61%	7.46%	1.619			5.53%	5.00%	0.903		
order 2-5	1.92%	2.31%	1.200		R	6.82%	8.09%	1.187		R	4.91%	4.72%	0.961		R
6+	3.71%	3.38%	0.912			9.31%	9.30%	0.999			4.38%	5.53%	1.262		
SES: Low	1.92%	2.31%	1.200		R	6.82%	8.09%	1.187		R	4.91%	4.72%	0.961		R
Middle	1.92%	2.76%	1.438			4.15%	7.30%	1.759	**	*	3.14%	3.48%	1.108		
High: n/a															
Uneducated	1.92%	2.31%	1.200		R	6.82%	8.09%	1.187		R	4.91%	4.72%	0.961		R
Educated	1.32%	1.09%	0.828			4.39%	13.54%	3.083	**	*	4.14%	6.11%	1.474		
Monogamous	1.92%	2.31%	1.200		R	6.82%	8.09%	1.187		R	4.91%	4.72%	0.961		R
Polygamous	1.69%	2.28%	1.347			8.21%	7.57%	0.922			5.59%	4.34%	0.776		
Unmarried: n/a															
Serrer	1.92%	2.31%	1.200		R	6.82%	8.09%	1.187		R	4.91%	4.72%	0.961		R
Other ethn	0.76%	2.26%	2.951	***	**	5.02%	4.27%	0.850			4.54%	2.78%	0.613	*	*
Num obsn:	8,922					12,849					7,963				
Deaths:	107					291					169				

Notes: The two-tailed test significance levels are: * = 20% (t-statistic = 1.282), ** = 10% (t = 1.645), and *** = 5% (t = 1.960). The first significance level shows if the sex mortality ratio is significantly different from 1.0 (equality), and the second if it is significantly different from that of the reference (R) child. Children of unmarried mothers were dropped due to the very small number of deaths among this group. By definition, there are no cases of high socioeconomic status in the EMIS Senegal study area.

The hypothesis that poorer families will discriminate more between children, acting to increase levels of relative female mortality, finds limited support in Bamako and no support elsewhere. In Bamako, low socioeconomic status is associated with significantly higher female relative risks among children aged under 1 year. For the 6-15 month age group, for whom excess female mortality is evident, the same pattern of risks occurs although differences are insignificant.

In the other study areas, girls of wealthy families appear to face higher relative mortality risks. In Bobo-Dioulasso, the sex mortality ratios for high SES children are high for all age groups, and is significantly greater than that of other classes at the 5% level for the 1-23 month age group. However, no systematic pattern of relative risks is apparent for the low and middle SES levels. In rural Senegal, high sex mortality ratios are also observed for the middle class, the highest SES category defined for the area. This pattern occurs for children of all ages, although it never attains the 10% level of significance.

Household socioeconomic status is closely related to mother's education, and the inclusion of both sets of variables in the equation could be masking the hypothesized relationship. However, when mother's education variables are omitted from the equations, neither the estimated coefficients for SES nor their t-statistics are substantially altered.

Mother's education appears to have little impact on relative mortality risks by sex. Only for children aged 6-15 months in Bamako and Senegal is there some slight evidence that mother's schooling affects sex mortality risks. And here, children of mothers reporting some education exhibit higher female-to-male sex mortality ratios at the 20% level of significance. The hypothesis that mother's schooling causes relative female mortality risks to fall is therefore rejected in all EMIS areas.

The hypothesis that relative female mortality will increase with rising birth order is also not confirmed in any of the areas. No systematic pattern of sex mortality risks by birth order is evident for Bobo-Dioulasso, rural Senegal, and infants in Bamako. Regarding Bamako children aged 12 months and above, the female-to-male mortality risk ratios tend to be greater for those of birth order one when compared to those of birth order 2-5. This finding of higher relative female mortality at the lowest birth order is significant at the 5% level for the toddler and 16-23 month age groups. In addition, toddler girls of birth order 6 and above experience relative mortality risks that are still lower, a difference that is significant at the 10% level. In fact, the estimated sex mortality ratio of high birth order toddlers is just half that of children of order 2-5 and one-fifth of those of order 1. Clearly, the hypothesis that female relative risks will rise with birth order is not verified in any of the EMIS data sets and the inverse appears to occur for toddlers in Bamako.

· Finally, higher sex mortality ratios are documented for rural Senegal than in either of the urban areas for children aged 1-23 months and especially 1-5 months. To further study the geographic pattern of sex mortality risks, a logit regression was estimated on the combined three EMIS data sets (results not shown). In this exercise, the probability of dying was regressed on the same set of independent variables, with the exception that dummy variables (and sex interaction terms) for EMIS study areas replaced the ethnicity variables. The results showed that, even after controlling for birth order, mother's schooling and marital status, and household socioeconomic status, girls aged 1-5 months in the rural Senegalese study area remained at a significant disadvantage when compared to those in Bamako and Bobo-Dioulasso.

Ethnicity often appears to have a significant effect on the relative risks of death by sex. For Bamako, all ethnic groups in general exhibit low sex mortality ratios for the 1-5 month age group and high ratios for the 6-15 month age group, suggesting that much variation in relative risks by age is independent of behavior specific to one or several ethnicities in the city. That said, there are significant differences in estimated mortality risks by sex between different ethnicities. In particular, for the age group 6-15 (when excess female mortality was documented) sex mortality ratios are especially high for the Sarakole, Malinke and, to a lessor degree, Bambara. In fact, if the Sarakole and Malinke were aggregated to a single group, their sex mortality ratio would be significantly greater than that of all other groups at the 5% level. Interestingly, compared to other ethnic groups high female relative risks among the Sarakole, Malinke and Bambara appear to be caused more by low levels of male mortality than by elevated levels of female risk. Female and male mortality risks are roughly equal for other ethnicities, which make up almost 40% of the sample.

In Bobo-Dioulasso, the effect of ethnic affiliation on relative risks by sex is less evident. The Mossi ethnicity seems to distinguish itself from all others, displaying a higher sex mortality ratio for ages 1-5 months and lower for all other age groups, although these differences are rarely significant. Concerning EMIS-Senegal, the mortality risks of Serrer boys and girls appear to roughly equal at all ages for children with the modal (reference) characteristics. In striking contrast, the Wolof (who make up the large majority of the "other" ethnicity) exhibit an extremely high sex mortality ratio for ages 1-5 months - almost 3-to-1 - and low ratios for older ages. As for Bamako, this high ratio appears to be caused more by comparatively low male mortality rather than high female mortality.

Finally, children aged 12 months and above born to monogamous mothers in Bamako and Bobo-Dioulasso often display significantly higher relative female mortality risks when compared to those of polygamous and/or unmarried mothers. In rural Senegal, the sex mortality ratios are similar for children of monogamous and polygamous mothers; the unmarried category was dropped due to the small number of observations in this area.

Discussion

At the end of this analysis, we are left with a puzzle. On the one hand, sex differentials in mortality for specific age groups and areas have been clearly documented. Excess female mortality that is statistically significant at the 5% level exists for ages 1-5 months in a rural area in Thiès, Senegal, for 6-15 months in the combined urban areas of Bamako and Bobo-Dioulasso, and for 16-23 months in the city of Bamako alone. These results confirm the findings of previous studies of Bamako and Senegal showing the existence of excess female mortality risks for young children at various ages.

On the other hand, despite a thorough analysis of relatively large and detailed longitudinal data sets, the causes and specific mechanisms of these patterns of differential mortality remain unclear. Concerning the direct, biological causes of death, girls were not found to be particularly vulnerable to measles, nor boys to respiratory diseases, in contrast to results of several other researchers.

Excess female infant and child mortality is generally thought to be caused by widespread discrimination against girls in the provision of nutrition or health care. Yet the treatment of girls and boys was found to be very similar in terms of supplemental feeding, weaning, medical care and vaccinations. In particular, the median age at the introduction of non-breastmilk and at weaning is nearly identical for boys and girls in each of the study areas. Girls aged 1-5 months in rural Senegal were more likely than boys to receive modern medical care prior to death. Girls aged 6-15 months in Bobo-Dioulasso, who faced a greater risk of dying from measles, were also found to have a higher probability of being vaccinated against the disease. However, in Bamako and Senegal, parents do appear to be slightly more willing to provide multiple DPT+P vaccinations for sons, which entail considerable attention and effort on their part.[27] Thus, while there is some sparse evidence of discrimi-natory behavior against girls, on the whole the results of this study do not support the contention that excess female mortality in the Sahel is due to widespread, systematic discrimination against daughters in the intrafamily provision of health care and nutrition.

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[27] This finding, while significant at only the 20% level, is buttressed by similar, highly significant results for *tetracoq* and polio vaccinations from DHS data (Mbacké et LeGrand (1991)).

Concerning the more ultimate, socioeconomic and demographic determinants of differential mortality, little or no support was found for any of the initial hypotheses. In particular, sex mortality differentials are generally not more pronounced among poorer families, where tight resource constraints were hypothesized to give rise to discrimination in parents' allocative decisions. Mother's educational attainment does not appear to influence differential mortality by sex to any significant degree. No relationship was found between birth order and relative female mortality. This last result indicates that, to the extent that parents discriminate against girls or boys as their relative numbers in the family increase, the degree of discriminatory treatment is roughly the same for both sexes. Finally, the geographic pattern of sex mortality differentials is at odds with the hypothesis that excess female mortality will occur predominately in urban areas, where the availability of expensive medical treatment should give rise to discrimination in favor of more highly valued sons.

A further puzzle is why the estimated sex mortality ratios vary widely across narrow age ranges and between ethnic groups. One explanation is that this is simply a coincidence, an artifact of the size of the data sets. Results from other studies provide evidence that at least some of the variation by age does occur. Cantrelle *et al.* (1986), in an analysis of data from the ORSTOM population laboratory located in proximity to the EMIS study area, found that the female-to-male sex mortality ratio was 1.21 for the post-neonatal period and 0.87 for the toddler period, versus 1.23 and 0.95 for the EMIS, respectively. They also report relatively higher male mortality for children aged 1-5, a finding that is consistent with EMIS data for children aged 1-2.

Research on Bamako, however, indicates that the age range of excess female mortality is probably wider than that documented with EMIS data. Fargues and Nassour (1988), in a study of Bamako death certificates, report excess female mortality starting at 4 months and continuing through the child (1-4 year) age group. According to Mbacké and LeGrand (1991), DHS-Mali data for urban areas show girls aged 3-11 months and, to a lessor degree, 1-4 years facing higher relative mortality risks than boys during the 1982-87 period.[28]

To the extent that substantial variation in sex mortality differentials by age does occur, what could explain it? If these differentials are caused by discrimination based on children's long-term economic or social values to their families, then the rationale for discrimination should not greatly change by age. What other factors could underlie a change in parents' attitudes and behavior toward their children to the extent implied by the sex mortality ratios?

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[28] Note that this study also documented considerable variation in sex mortality ratios between age groups and time periods.

One possibility is that the mechanisms of discrimination - as opposed to its underlying rationale - are age-specific. Research on Bangladesh, for example, has shown that the age pattern of excess female mortality closely follows that of discrimination in non-breastmilk foods, starting in the second half-year of life with the introduction of supplementary foods and becoming most pronounced at the time of weaning.[29] In the words of Koenig and D'Souza (1985), "Sex-biased behavior related to feeding thus appears to become important when parents are forced to make selective decisions about the allocation of scarce and costly familial resources such as supplementary food." Yet, if this is the explanation, what possible mechanisms could explain the observed patterns of mortality by sex in the three EMIS areas?

An alternative explanation is that the age pattern of mortality differentials is caused by cultural practices that are closely tied the child's age or level of physical development, but unrelated to discrimination based on parents' perceptions of the relative worth of their children. Such behavior could also explain the considerable variation in mortality by sex for different ethnic groups. Some ethnicities, including the Sarakole and Malinki of Bamako, exhibit comparatively high female relative risks for all ages under study. Others display very high female relative mortality risks for certain ages and low risks for others; the Wolof of Senegal are the most striking example of this.

In Subsaharan Africa, female circumcision, sex-specific food taboos, child fosterage practices, and even the piercing of girls' ears in unhygienic conditions are examples of this type of behavior. For instance, it is common knowledge that female circumcision is frequently practiced on girls aged 40 days to about 6 months by many ethnic groups in Bamako including the Malinke, Sarakole and Bambara. This operation, like ear piercing, can lead to higher mortality from infections (including tetanus) and resulting greater frailty. The fact that female circumcision is less common among residents of Bobo-Dioulasso may provide an explanation for the lesser degree of excess female mortality observed for the 6-15 month age group, when compared to Bamako. However, female circumcision is not practiced by either the Serrer or Wolof in Senegal and cannot underlie the extremely high relative female mortality risks observed for Wolof children aged 1-5 months.[30]

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[29] *Cf*. Brown *et al*. (1982), D'Souza et Chen (1980), D'Souza *et al*. (1988), Koenig et D'Souza (1985), Koenig et Wojtyniak (1987), Phillips *et al*. (1987), et Muhuri et Preston (1991).

[30] Both EMIS Bamako and Senegal contain reported deaths from tetanus which are probably subject to large misreporting errors. It is nonetheless suggestive that the percentage of girls aged 1-23 months dying from this disease is greater at the 5% level of significance in Bamako and the 20% level in Senegal. Moreover, the

Further research is needed if one is to understand the underlying reasons for mortality differentials by sex in the Sahel. EMIS data, like that of the DHS, are not well designed for the analysis of health behavior. Different types of data and approaches are required. Anthropological studies could provide essential missing information on the differential treatment of boys and girls. These studies would optimally include an analysis of health and childcare-related behaviors, and would pay particular attention to the interplay between cultural attitudes and the availability, perceived cost and actual use of different preventive and curative health care options in different areas. The social and economic roles of boys and girls, the resulting long-term expected values to their families, and systematic differences between ethnic groups should also be examined. Microeconomic methodologies, along the lines of the Cebu (Philippines) studies, could be equally important for the quantitative, causal analysis of family health behavior.

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highest percentage of reported tetanus deaths occurs for girls aged 1-5 months in Senegal.

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Appendix

Hazard Analysis of Sex Mortality Differentials

Table A-1. Estimated Logit Regression Coefficients and T-Statistics: Bamako

	Post-neonatal		Toddler (12-23)		1-23 months		1- 5 months		6-15 months		16-23 months	
	Coef	t-stat	Coef	t-stat	Coef	t-stat	Coef	t-stat	Coef	t-stat	Coef	t-stat
Female	-0.027	-0.119	0.264	0.898	0.075	0.413	-0.501	-1.473	0.521	2.039	-0.228	-0.538
Parity 1	0.474	2.492	-0.508	-1.659	0.145	0.892	0.246	0.876	0.346	1.504	-0.363	-0.950
" & girl	-0.106	-0.382	0.948	2.344	0.261	1.142	0.007	0.016	-0.078	-0.251	1.388	2.597
Parity 6+	-0.146	-0.689	0.114	0.474	-0.056	-0.35	0.048	0.168	-0.093	-0.394	-0.037	-0.116
" & girl	0.097	0.335	-0.680	-1.764	-0.154	-0.671	0.326	0.802	-0.429	-1.300	-0.222	-0.408
Unmarried	0.252	1.165	1.170	3.976	0.577	3.249	0.061	0.193	0.713	2.807	1.022	2.698
" & girl	-0.023	-0.071	-1.467	-3.316	-0.543	-2.093	0.360	0.753	-0.704	-1.981	-1.432	-2.322
Polygamous	-0.048	-0.274	0.262	1.187	0.076	0.552	-0.190	-0.759	0.180	0.900	0.190	0.664
" & girl	0.238	0.982	-0.547	-1.698	-0.060	-0.31	0.220	0.600	-0.150	-0.561	-0.188	-0.418
M Educated	-0.257	-1.475	-0.420	-1.697	-0.320	-2.245	0.167	0.709	-0.638	-2.901	-0.401	-1.287
" & girl	0.129	0.525	0.229	0.670	0.163	0.812	-0.253	-0.700	0.460	1.609	0.260	0.547
SES middle	0.225	1.327	-0.399	-1.561	0.018	0.129	0.249	1.059	-0.049	-0.234	-0.254	-0.790
" & girl	-0.487	-1.942	0.009	0.024	-0.317	-1.53	-0.809	-2.055	-0.144	-0.504	-0.094	-0.185
SES high	-0.079	-0.320	-0.703	-1.849	-0.273	-1.323	-0.451	-1.161	-0.202	-0.680	-0.258	-0.616
" & girl	-0.658	-1.701	0.398	0.784	-0.290	-0.957	-0.033	-0.057	-0.334	-0.805	-0.576	-0.770
Malinke	-0.144	-0.627	-0.110	-0.368	-0.130	-0.715	-0.285	-0.916	-0.056	-0.204	-0.037	-0.098
" & girl	0.410	1.329	0.120	0.287	0.311	1.249	0.598	1.318	0.254	0.722	-0.089	-0.152
Sarakole	-1.214	-2.829	0.169	0.501	-0.522	-2.017	-0.837	-1.748	-0.748	-1.702	0.148	0.335
" & girl	0.772	1.446	0.229	0.506	0.482	1.425	0.486	0.706	0.781	1.509	-0.117	-0.174
Poular	0.096	0.448	0.009	0.030	0.088	0.5	-0.172	-0.567	0.362	1.451	-0.236	-0.543
" & girl	0.057	0.180	-0.579	-1.165	-0.167	-0.63	0.546	1.185	-0.612	-1.640	-0.019	-0.028
Other eth	0.070	0.389	-0.020	-0.082	0.051	0.347	-0.524	-1.912	0.344	1.619	0.192	0.619
" & girl	-0.012	-0.046	-0.149	-0.406	-0.078	-0.359	0.587	1.412	-0.327	-1.109	-0.505	-0.981
Month 4- 5							-0.698	-4.246				
4- 7	0.150	1.165			0.137	1.053						
8-11	0.297	2.341			0.291	2.284			0.716	4.892		
12-15					0.059	0.431			0.498	3.213		
16-19			-0.410	-2.554	-0.338	-2.149						
20-23			-0.662	-3.734	-0.591	-3.394					-0.252	-1.306
Constant	-4.358	-24.535	-4.204	-18.814	-4.312	-23.93	-4.066	-18.398	-5.009	-22.676	-4.505	-15.761
Num obsn:	25358		20863		28007		17391		23688		13509	
Deaths:	382		213		585		172		312		111	

Note: The omitted reference categories are: birth order 2-5, of Bambara ethnicity, of mothers who are monogamously married, with no education, and of low socioeconomic status.

Table A-2. Estimated Logit Regression Coefficients and T-Statistics: Bobo-Dioulasso

Variable:	Post-neonatal Coef	t-stat	Toddler (12-23) Coef	t-stat	1-23 months Coef	t-stat	1-5 months Coef	t-stat	6-15 months Coef	t-stat	16-23 months Coef	t-stat
Female	-0.034	-0.128	0.167	0.501	0.095	0.461	0.001	0.001	0.096	0.332	0.020	0.051
Parity 1	0.310	1.587	0.410	1.615	0.345	2.226	0.639	2.225	0.185	0.810	0.327	1.042
" & girl	0.036	0.130	-0.507	-1.442	-0.186	-0.862	-0.189	-0.432	-0.003	-0.010	-0.423	-0.958
Parity 6+	-0.732	-3.195	-0.262	-1.006	-0.527	-3.075	-0.513	-1.457	-0.610	-2.510	-0.431	-1.309
" & girl	0.471	1.532	-0.343	-0.955	0.125	0.535	0.719	1.483	0.129	0.394	-0.308	-0.671
Unmarried	0.211	0.741	0.528	1.540	0.338	1.543	0.536	1.400	0.274	0.828	0.181	0.395
" & girl	0.058	0.149	-0.522	-1.061	-0.159	-0.520	0.098	0.173	-0.167	-0.381	-0.528	-0.735
Polygamous	0.384	2.266	0.214	0.975	0.328	2.436	0.395	1.480	0.384	2.023	0.118	0.436
" & girl	-0.270	-1.116	-0.392	-1.297	-0.324	-1.712	-0.664	-1.617	-0.306	-1.172	-0.113	-0.304
M Educated	-0.004	-0.021	-0.144	-0.561	-0.041	-0.264	-0.067	-0.227	-0.055	-0.247	-0.048	-0.154
" & girl	-0.268	-0.959	-0.090	-0.256	-0.218	-0.995	-0.367	-0.798	-0.019	-0.064	-0.506	-1.108
SES middle	0.024	0.128	-0.053	-0.223	-0.005	-0.031	-0.051	-0.177	0.033	0.160	-0.038	-0.129
" & girl	0.064	0.246	-0.496	-1.398	-0.159	-0.758	0.092	0.216	-0.125	-0.439	-0.440	-0.986
SES high	-0.759	-2.257	-1.174	-2.262	-0.902	-3.200	-0.797	-1.509	-0.867	-2.173	-1.082	-1.795
" & girl	0.713	1.670	0.990	1.626	0.779	2.240	0.892	1.316	0.551	1.112	1.227	1.726
Bobo ethn	-0.180	-0.749	-0.187	-0.623	-0.177	-0.943	0.024	0.067	-0.221	-0.805	-0.320	-0.872
" & girl	0.041	0.121	0.487	1.175	0.177	0.678	-0.516	-0.913	0.267	0.722	0.675	1.346
Dioula,Daf	-0.183	-0.841	0.096	0.376	-0.040	-0.240	0.114	0.354	-0.130	-0.532	-0.119	-0.376
" & girl	0.056	0.182	0.372	1.011	0.146	0.623	-0.143	-0.302	0.195	0.580	0.434	0.955
Other ethn	-0.148	-0.720	-0.532	-1.859	-0.274	-1.644	-0.293	-0.871	-0.137	-0.590	-0.567	-1.661
" & girl	-0.084	-0.288	0.661	1.688	0.174	0.749	-0.055	-0.114	0.183	0.575	0.337	0.690
Month 4- 5							-0.906	-4.644				
4- 7	0.036	0.247			0.033	0.222						
8-11	0.563	4.240			0.562	4.220			1.027	6.552		
12-15					0.013	0.086			0.479	2.769		
16-19			-0.098	-0.605	-0.083	-0.528						
20-23			-0.138	-0.840	-0.129	-0.803					-0.040	-0.234
Constant	-4.191	-20.379	-4.233	-16.776	-4.237	-22.514	-4.316	-14.193	-4.729	-19.656	-4.094	-14.143
Num obsn:	20117		17834		28875		13684		19243		11721	
Deaths:	338		224		562		131		290		141	

Note: The omitted reference categories are: birth order 2-5, of Mossi ethnicity, of mothers who are monogamously married, with no education, and of low socioeconomic status.

Table A-3. Estimated Logit Regression Coefficients and T-Statistics: Senegal

	Post-neonatal		Toddler (12-23)		1-23 months		1-5 months		6-15 months		16-23 months	
	Coef	t-stat	Coef	t-stat	Coef	t-stat	Coef	t-stat	Coef	t-stat	Coef	t-stat
Female	0.302	1.389	-0.059	-0.284	0.095	0.640	0.186	0.505	0.180	0.872	-0.041	-0.152
Parity 1	0.014	0.043	-0.239	-0.816	-0.130	-0.601	0.027	0.048	-0.408	-1.196	0.124	0.380
" & girl	-0.047	-0.114	0.401	1.016	0.193	0.675	0.365	0.544	0.322	0.738	-0.065	-0.134
Parity 6+	0.641	3.448	-0.168	-0.856	0.246	1.865	0.672	2.028	0.329	1.821	-0.118	-0.481
" & girl	-0.337	-1.325	0.243	0.873	-0.041	-0.222	-0.281	-0.650	-0.181	-0.707	0.282	0.804
Polygamous	0.259	1.443	-0.008	-0.043	0.127	1.002	-0.127	-0.393	0.196	1.118	0.134	0.609
" & girl	-0.262	-1.070	-0.127	-0.487	-0.188	-1.059	0.117	0.279	-0.267	-1.079	-0.222	-0.679
M Educated	-0.345	-0.581	-0.327	-0.634	-0.336	-0.862	-0.380	-0.370	-0.458	-0.773	-0.176	-0.294
" & girl	0.698	0.977	0.532	0.766	0.624	1.267	-0.377	-0.261	1.014	1.446	0.444	0.523
SES middle	-0.489	-2.113	-0.334	-1.533	-0.414	-2.610	-0.001	-0.002	-0.517	-2.278	-0.460	-1.657
" & girl	0.441	1.471	0.190	0.614	0.325	1.515	0.185	0.395	0.407	1.334	0.146	0.361
Other ethn	-0.477	-2.285	-0.179	-0.944	-0.319	-2.281	-0.931	-2.225	-0.320	-1.640	-0.082	-0.353
" & girl	0.137	0.493	-0.475	-1.651	-0.157	-0.796	0.908	1.828	-0.348	-1.227	-0.462	-1.292
Months 4-5							-0.930	-4.299				
4- 7	0.137	0.862			0.136	0.856						
8-11	0.611	4.213			0.609	4.201			0.904	5.617		
12-15					0.375	2.456			0.671	3.996		
16-19			-0.167	-1.117	0.208	1.302						
20-23			-0.126	-0.848	0.248	1.558					0.041	0.263
Constant	-4.273	-22.295	-3.436	-20.967	-4.021	-26.497	-4.269	-14.781	-4.328	-22.383	-3.690	-18.394
Num obsn:	13229		12122		25351		8922		12849		7963	
Deaths:	296		271		567		107		291		169	

Note: The omitted reference categories are: birth order 2-5, of Serrer ethnicity, of mothers who are monogamously married, with no education, and of the lower socioeconomic status. Children of unmarried mothers were dropped due to the very small number of deaths among this group. By definition, there are no cases of high socioeconomic status in the Senegal study area.

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