Sons Or Daughters: A Cross-Cultural Study Of Sex Ratio Biasing And Differential Parental Investment

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Abstract

Survivorship of children is dependent upon numerous variables, including the role that preferential treatment may play in biasing the birth and survival of sons and daughters across cultures. This study draws upon an evolutionary approach by examining a theory referred to as the "Trivers-Willard hypothesis" concerning condition-dependent sex allocation and differential parental investment. Previous research on humans concerning this hypothesis tends to be restricted to one cultural group and thereby limited in sample size. For this study, nationally representative household survey data collected by the Demographic and Health Surveys (DHS+) program across 35 countries was used to test biological, resource-oriented, and behavioral aspects affecting maternal condition, sex allocation, and parental investment in humans. The units of analysis for this study were the mothers and their lastborn child (N = 128,039 woman-child pairs). A series of hierarchical regressions were executed to empirically investigate the TW hypothesis in humans. Scales were developed for maternal socioeconomic resources (MSR), maternal biological condition (MBC), prenatal care for the lastborn child (PCL), and health-seeking for the lastborn child (HSL). MSR was measured by relative household economic status, woman's and partner's education, and residence in an urban/rural setting. MBC was defined by body mass index, pregnancy status and duration, and breast-feeding status. PCL was an index for type of prenatal care received, number of prenatal visits, and assistance during delivery of the lastborn child. Lastly, HSL measured indicators of treatment for diarrhea and immunizations received by the lastborn child. Across the 35 countries, the analyses did not support the Trivers-Willard hypothesis. However, there is evidence of regional and country level differences.

INTRODUCTION

"Once you've learned to think of a herring gull as an equal, the rest is easy." – William Drury (Trivers 2002, p. 57)

While there are academic endeavors that can wrap themselves neatly around a circle of concepts, sex ratio research is certainly not one of them. Explorations of what drives any sexual species to produce one of merely two potential outcomes – a daughter or a son – has garnered remarkable attention for several centuries. Indeed, sex determination or adjustment has been attributed to timing of ovulation, maternal hormones, parental chromosomes, sexual positions, phases of the moon, mating opportunities, available nutritional resources, environmental stressors (e.g., drought, famine, flood), temperature changes (viz., across reptilian species), presence of kin and non-kin, the probability of infant survivorship, and even stochastic variation (Andersson 1994, Brewis 1993, Brown and Silk 2002, Cameron 2004, Ciofi and Swingland 1997, Clutton-Brock and Iason 1986, Grant 1998, Hamilton 1967, Hardy 1997, Hardy 2002, Hrdy 1987, Hrdy 1988, James 1987). Sex ratio differences – what causes them and what maintains them – have been studied in a wide spectrum of species, ranging from spinach to whales (e.g., Freeman et al. 1994, Wiley and Clapham 1993).

What is noteworthy is the extent to which research has attempted to account for such variations in elements of gestation, survivorship, and parenting style. Such research has crossed the domains of anthropology, sociology, psychology, biology, and evolutionary theory. The evolutionary angle from which academics tend to approach the topics of conception, gestation, survivorship, and parenting is understandably from an evaluation of reproductive fitness and the adaptations that are predicted to come into play in order to maximize it. The heart of the theory reviewed in this paper is embedded in the notion that nonhuman and human animals actually do behave in a manner so as to optimize reproductive success (i.e., number of viable offspring produced), measured not only in parity but also in post-parturition investment in the survivorship of offspring.

Richard Alexander once wrote: "My own view of the optimal outcome would be for the significance of evolution to become so widely known and so thoroughly embedded in the understanding of all those working in human-oriented disciplines, that its tenets can be employed, without fanfare, when they are useful, and ignored or discarded when they are not" (1988, p. 339). A model concerning sex-biased parental investment is evaluated in this light, drawing upon evolutionary and cultural approaches in order to appreciate not only how evolutionary adaptations operate within cultures but also how humans cross-culturally may be

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outrightly invoking an evolutionary strategy in the treatment of their children. As Cronin points out, the acceptance of natural selection and sexual selection as forces of evolution are thankfully, at this point, "...for modern Darwinism...a storm in a teacup" (1991, p. 236).

This study focuses on a theory referred to as the "Trivers-Willard hypothesis" concerning condition-dependent sex allocation and differential parental investment in humans (Trivers and Willard 1973). The central idea is that within a polygynous social mating structure, where reproductive variance is higher for males than for females as an intrinsic function of polygyny, mothers in optimal condition (defined by high status, good health, and abundant resources) are more likely to produce and invest in male offspring whereas mothers in poor condition (defined by low status, poor health, and resource deprivation) are more likely to produce and invest in female offspring. Although the Trivers-Willard hypothesis has been demonstrated in many animal species, its application and explanation for sex ratio determination across taxa have been notably inconsistent, sometimes even within species (e.g., Cockburn 1994, Cockburn et al. 2002). For example, animals exhibiting condition-dependent sex allocation and differential parental investment include: fur seals, elephant seals, opossums, red deer, mule deer, zebras, spider monkeys, horses, humpbacked whales, chimpanzees, zebra finches, reindeer, hamsters, rats, coypus, mouse lemurs, and wood rats. Species where the theory has demonstrated less applicability include sea lions and chickens with inconsistent support evident across studies on bison, lion tamarins, certain species of ungulates, pigs, mice, rhesus monkeys, and baboons[1].

In one study, food-restricted hamster mothers produced smaller, female-biased litters and by the 15th day of the study, they had reduced their litters by half, whereas no such mortality pattern was present in the other food conditions (Huck et al. 1986). Moreover, of the food-restricted pups, males and females weighed less than all others by the 25th day of the study. Similar tests of maternal condition and its impact on the sex ratio of litters have yielded moderate support for the TW hypothesis (e.g., coypu; Gosling 1986). In the wild boar, for example, mothers apparently adjust their litter size and sex ratio in that maternal condition, as measured by weight and size, was associated with litter size (Fernández-Llario et al. 1999). A study on house mice by Krackow (1993) examined fitness differentials based on body weight variation and found a positive effect for males but not for females. Yet in others, support is absent on account of social variables purported to influence the sex ratio (e.g., yellow-bellied marmots; Armitage 1987; spotted hyaenas; Hofer and East 1997).

Nonetheless, several studies seem to suggest that the TW hypothesis finds its strongest support in ungulates such as reindeer and red deer (Kojola 1997). For example, Kucera (1991) demonstrated that heavier and fatter (as measured by kidney-fat index) female mule deer produced male-biased litters. In fact, Hewison and Gaillard (1999) argue that the predictions are supported in species such as red deer, reindeer, bighorn sheep, and fallow deer because these species most satisfy the assumptions of the theory.

Its applicability to humans is just as open to debate. While several studies on humans have found support for the Trivers-Willard hypothesis, others have provided inconclusive results on account of differences in measuring evidence of sex ratio biasing and parental resource allocation biasing (Keller et al. 2001). For example, several studies have indicated a weak to moderate Trivers-Willard effect for lower status groups but no real effect in the higher status groups, regardless of how status (or maternal condition) was actually measured (e.g., Borgerhoff Mulder 1998, Chacon-Puignau and Jaffe 1996, Webster 2004). On the other hand, Freese and Powell (1999) were not able to support the TW hypothesis in humans in that sex-biased differences in socioeconomic investment were absent in their study while Mealey and Mackey (1990) showed that, among 19th century Mormons, higher order wives produced higher sex ratios. Interestingly, they also make note that a threshold effect may exist in humans in that the TW hypothesis "…cannot by itself predict which species will exhibit sex ratio biases under which conditions, or whether sex ratios will exhibit continuous variations or respond to some environmental threshold" (1990, p. 92).

The data required for such an analysis in humans has often been unavailable or problematic in its measurement, and differences across cultures – for example, the practice of selective neglect and/or infanticide – may confound otherwise potentially ethologically comparative analyses. As a result, there is a theoretical and practical need for additional examination of condition-dependent sex allocation and differential parental investment in humans. The main objective of this study is to extend the application of the animal model to include human reproductive and parental behavior thereby revealing how humans produce and enhance the survival of their male and female offspring based on an evolutionary principle concerning reproductive success. Essentially, what might a cross-cultural test of the hypothesis yield for our species? The idea is to under-

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[1] For good reviews of studies addressing sex ratio variation and differential parental investment across various species (including humans) refer to any of the following: Anderson and Crawford 1993, Brown 2001, Clutton-Brock and Iason 1986, Caley and Nudds 1987, Cameron 2004, Carranza 2002, Cockburn et al. 2002, Hamilton 1967, Hardy 1997, Hewison and Gaillard 1999, Hrdy 1988, James 1987, Lazarus 2002, Pedersen 1991, Rosenfeld and Roberts 2004, Sheldon and West 2004, and van Hooff 1997.

stand the "survival of those who survive" (Trivers 2002, p. 64) and how or why their mothers let them live.

This study tests the Trivers-Willard hypothesis[1] by pursuing two specific aims. First, it will evaluate the significance of condition-dependent sex allocation of offspring among humans. The working hypothesis is that the sex of the child is predicted by maternal condition such that a mother who is "healthy and wealthy" will be more likely to have a son. A woman in sub-optimal condition regarding health and resources will, instead, more likely be the mother of a daughter. Secondly, the significance of differential parental investment among humans will be examined with the following working hypothesis in mind: Females of high status, abundant resources, and good health will be more likely to invest more resources in their male offspring than in their female offspring. Females at the other end of the condition continuum will tend to invest more in their female offspring. These questions will be examined in a multi-sample analysis spanning 35 developing countries from four regions around the world. This study will present an analysis of the TW hypothesis in humans by testing variables that may predict the sex allocation of the lastborn child and the parental behaviors differentially directed toward that child, thereby comparing the human model to patterns found in other animals.

As such, central assumptions of the theory concerning natural deviations from a 50/50 sex ratio in nature are the following: (a) the condition of the mother during the period of parental investment serves as a predictor of the condition of the offspring at the end of the parental investment period; (b) differences in offspring condition at the end of the period of parental investment persist through adulthood; and (c) in species where males exhibit less parental investment than females, males are expected to exhibit higher variance in reproductive success. In summary, according to Trivers and Willard, "...under certain well-defined conditions, natural selection favors systematic deviations from a 50/50 sex ratio at conception.…other things being equal, species showing especially high variance in male [reproductive success] (compared to variance in female RS) should show, as a function of differences in maternal condition, especially high variance in sex ratios produced" (1973, p. 90).

Interestingly, most tests of the TW hypothesis tend to focus on an abbreviated version without necessarily including – or at least, demonstrably excluding – some of the underlying predictions. While many studies readily focus on "good-condition mothers invest in sons," it should not be overlooked that the following parameters were also included: (a) the theory is expected to apply to species with small brood sizes, given cited empirical evidence – yet less so to species with larger litters; (b) compensatory growth, in response to malnutrition or maternal effects, for example, is deemed trivial in effect; (c) sex ratio at birth is assumed to be an indicator of parental investment; (d) and reproductive success of males is free to vary on account of "negligible" paternal care (Trivers and Willard 1973, p. 91). Which is to say that several central assumptions must be met in order for analysis to address the actual Trivers-Willard hypothesis, as outlined in the original paper. The role of polygyny and minimal parental investment by males is central to the assumptions of the theory.

In fact, variance in reproductive success is explained as "all or nothing" for males within a polygynous mating system whereas the contrast in reproductive success for females is of smaller disparity in that a female is more likely than not to successfully secure mating opportunities at some point. Although she will never be able to produce as many potential grandchildren as a male could, it is at least more probable that she will at least have the opportunity to try. In truly socially polygynous mating systems – such as those seen among herding or harem species – not all males are so fortunate. Hence, the greater disparity between the males who are outcompeted by other males in their access to females. While Clutton-Brock and Iason pronounce that "...the firmest conclusion that can be drawn from the distribution of observed trends in the sex ratio is that the distribution does not conform to the predictions of any single adaptive hypothesis" (1986, p. 367), it is all the more reason to apply an empirical test of one such as that provided by the Trivers-Willard hypothesis.

Precisely when parental investment begins and ends can be problematic in terms of measurement; most definitely, depending on the species in question. Nonetheless, it has been defined as "...any investment by the parent in an individual offspring that increases the offspring's chance of surviving (and hence reproductive success) at the cost of the parent's ability to invest in other offspring" (Trivers 1972, p. 139). Despite all their efforts and intentions, or because of all the variance in parental behaviors, not all parents watch their children grow up and produce grandchildren; there is also "the darker side of parenting" (Scheper-Hughes and Sargent 1998, p. 21). Indeed, the impact of parental under-investment – or disinvestment – ranges from passive neglect to active infanticide (Scrimshaw 1984). While 9% of all world cultures practice sex-selective infanticide (Hrdy 1999), most cases where human children do not survive would be more appropriately classified as selective neglect (Larme 1997).

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[2] Note that, in the research literature, the central hypothesis is sometimes interchangeably referred to as the "Trivers-Willard model" or as the "Trivers-Willard hypothesis" and thus abbreviated as TWM or TWH, respectively. In some cases it is cited as the "Trivers-Willard effect" when referring to particular predictions of the hypothesis. For the sake of clarity in this paper, the guiding theoretical framework is referred to as the "TW hypothesis" while the term "model" will indicate the analytical approach used to test the hypothesis, as measured in this study.

Extensive research has accumulated in the last years addressing what adaptive mechanisms may be driving the practice of infanticide as well as how cultural sanctions may be merely providing the framework in which "evolved decision rules" can operate (Hrdy 1999). In fact, much of the research on infanticide seems to support the Trivers-Willard hypothesis in that infanticidal trends are most evident where females have the smaller chance of reproductive success comparable to males (Beise and Voland 2002, Daly and Wilson 1984, Dickemann 1979, Gosden et al. 1999, Jeffery et al. 1984, Miller 1987). For example, Hrdy describes the role of the "daughter destroyers" within elite clans in India (1999, p. 326) and cites research revealing that among lower castes, genetic markers crossing caste boundaries serve as an indicator of females engaging in "marrying up" (i.e., hypergamy; Hrdy 1999, p. 340) in that the lower caste females have higher reproductive variance than their male counterparts. Among the elites, however, daughters are at a distinct disadvantage. As such, countries known to practice sex-selective infanticide are included in the analyses.

METHODS

Data source

The study population was drawn from 134,257 women in 35 countries who were interviewed between 1992 and 1998 as part of the Demographic and Health Surveys (DHS+) with funding from the US Agency for International Development[1]. DHS+ surveys are nationally representative samples by country and usually use multistage cluster sampling techniques. We selected all countries in the DHS+ datasets that collected complete data for maternal nutritional status, socioeconomic resources, and parental investment. These 35 countries are in the least developed and developing categories. Sub-Saharan Africa is represented by 21 countries, South Asia and the Near East/North Africa by three countries each, and the Caribbean/Latin America by eight countries. A list of all countries selected for this study and survey collection dates is presented, by region, in Appendix Table 1.

Sample

The youngest child for each mother was selected for the analyses and cases with missing data (4.6%) were excluded, leaving a final sample size of 128,039 mother-child pairs (weighted N = 124,371). The sample size per country ranged from 732 for Comoros to 5,361 for Guatemala, with an average of approximately 3,000 mother-child pairs. The exception was India, with a sample size of 21,839 (Appendix Table 1).

Note that the sampling techniques employed in the DHS+ surveys are designed to maximize the retrieval of information representing 100% of the population surveyed. DHS+ emphasizes the use of nonzero probability sampling. When this is not the case and a sample is not self-weighting, calculation of sample weights should be included in any inferential analyses of DHS+ data (Macro International Inc. 1996). That is, individual weights in almost all of the surveys are normalized so that if all of the women within a sample are included, the weighted and unweighted numbers of women should be equal. If selecting a sub-sample, then the weighted and unweighted sample sizes will differ. In order to ensure that analysis is representative of the entire population – and not just of the sample population – sample weights are provided with all data sets for proper parameter estimation; their significance being that they "...are often interpreted as the number of population units represented by each unit of the sample" (Häder and Gabler 2003, p. 124). Therefore, sample weights were included in the analyses.

Procedure

Women between the ages of 15-49 were interviewed by trained personnel using structured questionnaires. Response rates were generally above 95%. In each country, households were selected using a multistage clustering procedure. The surveys included questions related to maternal resources, biological condition, medical care, and health-seeking behavior. Data collection procedures are described in detail in ORC Macro (2005).

Scales

Four scales were developed relating to the biological, resource-oriented, and behavioral aspects affecting maternal condition, sex allocation, and parental investment in humans. Selection of the final set of variables are presented in Appendix Table 2 , along with brief descriptions and coding schemes. Stringent decision rules were applied to enhance the cross-species comparative focus of this study, and these are briefly reviewed here.

Maternal socioeconomic resources (MSR)

The four dimensions of household economic status were drawn from a previous study by Smith et al. (2003). Economic status was defined by level of basic needs met and number of assets owned. Basic needs are measured by whether the household has a finished floor, toilet facility, or access to piped or bottled water. Cheap assets include a radio, a television, or a bicycle; expensive assets include a refrigerator, motorcycle, or car. Households were classified as "destitute" if they have one or none of the basic needs and none of the assets. Households classified as "poor" have no more

[3] Dataset access can be initiated at the MEASURE DHS+ website: http://www.measuredhs.com/

than two of the basic needs and cheap assets. "Rich" households have at least two basic needs met and at least one expensive asset. Urban households received a higher score because urban living tends to provide women with more efficient access to resources (Madzingira 1993). The woman's level of education was included as a resource, and male contribution was measured by presence in the household and educational status.

Maternal biological condition (MBC)

Body mass index (BMI) was used as an indicator of the continuum of maternal condition. Higher BMI is used as an indicator of good condition, along with a categorical variable for under-nourished, healthy, or overweight. Current pregnancy and breast-feeding status were also included in order to differentiate between women on several important elements that constitute the mammalian female reproductive life cycle. Breast-feeding was predicted to have a negative effect on a mother's condition by placing a drain on her energy and nutrient intake (Brown 2001). Length of pregnancy (as opposed to pregnancy status by itself) was used as a positive indicator of maternal condition in that the very fact that a woman is able to be pregnant and especially to be able to maintain a pregnancy for any length of time are considered indicators of good condition (Haig 1999). Although any pregnancy naturally deprives a woman of necessary energy reserves (i.e., maternal depletion; Ellison 2001), the very fact that she is able to be pregnant and especially to be able to maintain a pregnancy for any length of time are considered indicators of good condition, especially given that malnourished and/or stressed women are more likely to miscarry (Kerr 1971). For this reason, current pregnancy duration was selected for the maternal health scale whereby women who were not pregnant were coded as zero for pregnancy duration.

Prenatal care for lastborn child (PCL)

This scale measured protective, risk-avoidance behaviors. Central to this scale is access to care and initial parental effort directed toward the maintenance of maternal and child health. Type of prenatal care was measured by amount and provider (none, non-medically trained, or medically trained provider). Measures for birth assistance included delivery at a medical facility and type of provider.

Health-seeking for lastborn child (HSL)

The overall HSL scale is not a measure of the child's health, but the parental response and prevention strategy experienced by the child. It serves as a direct measure of parental-initiated investment per lastborn child. Receipt of immunizations and age-relative compliance with immunization completion were included to provide each child with a score comparable to all other children, regardless of age. Note, though, that all eight vaccinations should ideally be given before the first birthday has been reached such that by the time they are 4 months old, children should have received five of the eight vaccinations (Smith et al. 2003). Furthermore, diarrhea in the developing world is particularly dangerous for children and the risk of dehydration cannot be underplayed; as such, the scale was coded to emphasize treatment-seeking. The highest score was assigned to children who received treatment and the lowest score assigned to those who did not receive treatment for a reported case of diarrhea.

Scale construction

Composite scores were created by standardizing and averaging the variables, and scale scores were standardized again for the hierarchical regressions; the specific means (M) and standard deviations (SD) should, by definition, tend toward a mean of zero and a standard deviation of 1. Listwise deletion was used in scale construction. Final determination of scales was based on a Cronbach's alpha > .60. The inter-item reliabilities for the four scales ranged from .63 for MBC to .85 for HSL. Internal consistency – a measure of scale reliability – serves as evidence of construct validity. For scale confirmation, the indicators were then correlated with the scales. The results of these correlations are presented in Table 1. While the diarrhea treatment variable did not correlate strongly with the scale to which it was assigned ($r = .24$, $p < .01$), the item was retained for theoretical considerations. It was necessary to include a measurement for diarrhea treatment-seeking behavior given that diarrhea is one of the main causes of mortality in children in developing countries. In this case, theoretical considerations overrode the weaker statistical justification for retaining that variable in the health-seeking behavior scale. Zero-order correlations between the scales ranged from .2 to .6. Detailed information regarding scale construction is in Guggenheim (2005).

Statistical analyses

A hierarchical cluster analysis involving Ward's linkage method was used to determine the pattern of association between cases based on discrepancies between the national at-birth sex ratio and the sex ratios within the current data. The cluster analysis utilized a composite score for each country using national estimates from the CIA and survey research data to measure similarities and differences in individual countries' deviation from their estimated at-birth sex ratio among children under five years of age.

A series of hierarchical regressions was performed in which multiple dependent criterion variables were analyzed sequentially according to a hypothesized causal

Table 1. Pearson correlations between scales and indicators.

	MSR	MBC	PCL	HSL
Whether woman lives in urban area	.715			
Household economic status	.778			
Woman's education	.802			
Male's educational value	.738			
Woman's BMI		.785		
Woman is malnourished/ healthy/overweight		.775		
Duration of current pregnancy, if pregnant		.544		
Woman currently breast-feeding (reversed)		.655		
Whether prenatal care received & care type			.770	
Number of prenatal care visits			.788	
Delivery assistance			.808	
Delivery took place at a medical facility			.824	
Child's diarrhea: untreated, absent, or received treatment in last 2 wks				.243
Whether child received BCG vaccination				.799
Whether child received measles vaccination				.742
Total number of DPT vaccinations received				.916
Total number of polio vaccinations received				.894
Percent recommended vaccinations received				.922

order. Because these dependent criterion variables were expected to causally influence each other, they were entered sequentially as criterion variables into a system of multiple regression equations with each hierarchically prior criterion variable entered as the first predictor for the next. Thus, each successive dependent variable was predicted from an initial set of ordered predictor variables, each time entering the immediately preceding dependent variable hierarchically as the first predictor, then entering all the ordered predictors from the previous regression equation. Thus, each successive regression entered all of the preceding dependent variables in reverse causal order to statistically control for any indirect effects that might be transmitted through them. Within this analytical scheme, the estimated effect of each predictor was limited to its direct effect on each of the successive dependent variables. The general format for these hierarchical multiple regressions was therefore as follows:

$$Y1 = X1 + X2 + X3$$
$$Y2 = Y1 + X1 + X2 + X3$$
$$Y3 = Y2 + Y1 + X1 + X2 + X3$$

This procedure was conceptually equivalent to a sequential canonical analysis (Gorsuch and Figueredo 1991, Figueredo and Gorsuch 2007), which controls statistically for any indirect effects of the predictors through the causally prior dependent variables.

In this study, the causal order of the dependent variables was: 1) maternal socioeconomic resources (MSR), 2) maternal biological condition (MBC), 3) prenatal care for the lastborn child (PCL), 4) sex of lastborn child (SEX), and 5) health-seeking for lastborn child (HSL). The causal order for the dependent variables is presented in Figure 1. Note, however, that this figure is simplified as it does not include the successive main effects and interaction terms. The order for the general linear models was:

MSR = REGION + COUNTRY
MBC = MSR + REGION + COUNTRY
PCL = MBC + MSR + REGION + COUNTRY
SEX = PCL + MBC + MSR + REGION + COUNTRY
HSL = SEX + PCL + MBC + MSR + REGION + COUNTRY

The effect of region and country on maternal socioeconomic resources (MSR) were examined first, given the prediction that they precede the measure for maternal condition (MBC) in explanatory power. That is, socioeconomic factors are predicted to be region- and country-specific. Resources available to each mother are, in turn, predicted to influence her biological condition (as measured by MBC). The next relationship examined is the effect of MSR and MBC in influencing levels of prenatal care for each lastborn child (PCL). The frequency and type of prenatal care are, in turn, predicted to determine the sex of that same child (SEX). Lastly, degree of health-seeking for the lastborn child (HSL) is hypothesized to be predicted by the sex of that child. The analyses also assess the residual effects of each previous variable in the analysis along with interactions by region and country.

These interaction terms have been included to measure whether the effect of any of the central predictors (MSR, MBC, PCL, SEX, and HSL) on the dependent variable of any given regression are moderated by REGION or COUNTRY. For example, if an interaction between REGION and MSR is significant and large in predicting PCL, this would indicate that the manner in which maternal resources impacts prenatal care varies

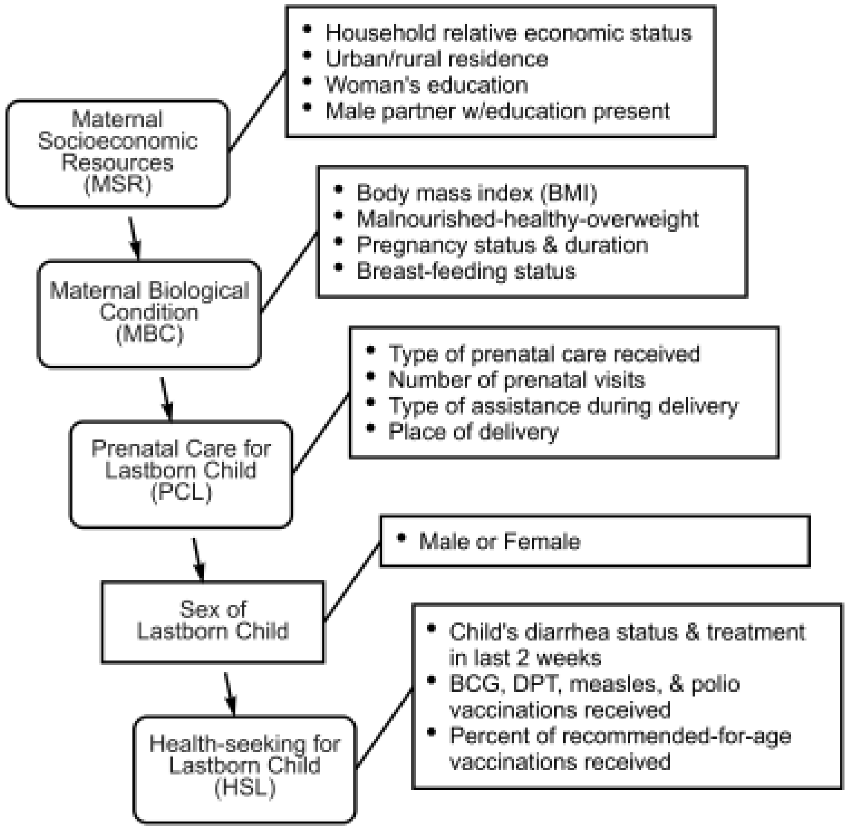

Figure 1. *Causal order for the dependent variables.*

as a function of regional or country differences. For this study, the conditional associations – as measured by the interaction terms – are crucial in determining to what extent cultural variance is at play here in addressing an evolutionary theory that has been difficult to demonstrate reliably in human populations. In essence, if the Trivers-Willard hypothesis applies to humans over and above what cultural differences may exist, then results from interaction terms in the forthcoming analyses should be nonsignificant or minimal. Additionally, as referenced earlier, sample weights were used in the analyses to ensure representative samples within each country.

RESULTS

Thirty-five countries were sampled across four regions: South Asia, Sub-Saharan Africa, the Caribbean/Latin America, and the Near East/North Africa. For the mothers across all four regions: 91% reported a male partner present, 13% were living in female-headed households at the time of the interview, 14% were malnourished, 10% were pregnant at the time of sampling, and 63% were breast-feeding. The mean age of the women across all regions was 27.8 years, with the average age at first marriage being 17.7 years and education averaging 3.8 years.

For the 22% of the sample reporting information for more than one child, the maximum number of children currently residing at home with the mother and under the age of five years was 4. The mean age of the lastborn child across all women was 19.7 months. Virtually all of the children (99%) were reported to have been breast-fed at some point. Additionally, 79% received the BCG vaccination, 53% received the measles vaccination, the average number of DPT and polio vaccinations was 2, and the mean percent of age-recommended vaccinations received was 72%. Variations by region and country are discussed in Guggenheim (2005).

Sex ratio of lastborn children

The number of males (65,190) to females (62,849) across all regions in the final sample selected for analysis yields a sex ratio of 1.037 (51% boys, 49% girls). Estimated sex ratios by country at birth and in the current sample are presented in Appendix Table 3. Preliminary interpretation of the discrepancy in the national at-birth sex ratios from the sex ratios of the current data was suggestive of interesting trends. Certain countries apparently deviate from the secondary sex ratio by becoming unusually female-biased (e.g., Uganda) while others deviate by becoming unusually male-biased (e.g., Turkey). Noteworthy, also, is that all three Near Eastern/North African countries yield male-biased trends as well as India; notwithstanding, these are the countries with prevalent son preference and significantly high infanticide rates.

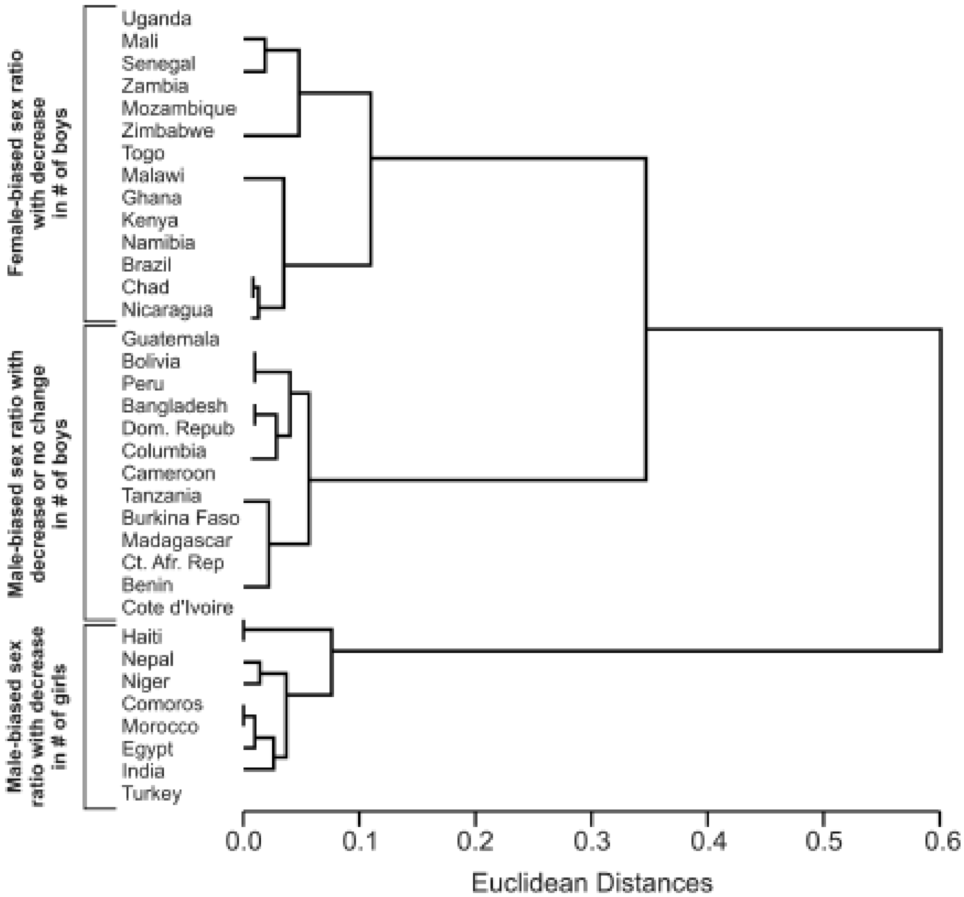

Figure 2. *Results of cluster analysis.*

Results reveal a distinctive pattern of three clusters, with the first break (Euclidean distance = 0.593) across two groups separating countries by those that decreased (or remained unchanged) in the number of males relative to females and those that decreased in the number of females relative to males within the under-five age group. The former group contains countries with male and female-biased sex ratios while the latter contains only male-biased countries. The second break (Euclidean distance = .343) distinguishes between a group that decreased in the number of males proportional to females, thereby producing female-biased sex ratios, and a group that either decreased or did not decrease in the number of males relative to females, thereby producing male-biased sex ratios.

The cluster tree yields three distinctive groups (see Figure 2). The top cluster, in italics, includes the female-biased countries that reflect a loss of males relative to females within the under-five age group. The center of the tree identifies the male-biased countries that did or did not decrease in number of males relative to females. And the bottom group, in bold, contains the countries that demonstrate a loss of females relative to males. The cluster analysis implies a proportional decrease over time from the estimated at-birth sex ratio in almost all countries.

Overview of modeling

Analyses involved a system of hierarchical regressions testing for the interaction and main effects of region, country and the four scales: maternal socioeconomic resources, maternal biological condition, prenatal care for lastborn child, sex of lastborn child, and health-seeking for lastborn child. Results are presented for each dependent variable as it is predicted by each set of independent variables and interactions following the sequence depicted in Figure 1.

Maternal socioeconomic resourcesIn the first general linear model, region and country together account for 22.6% of the variance in maternal socioeconomic resources (see Table 2). In fact, region accounted for 13.8% while country accounted for almost 12%, as indicated by R^2 for each variable. Additionally, Sub-Saharan Africa had the lowest mean for the maternal socioeconomic resources scale (M = -.32, SD = .82), and Latin America and the Caribbean had the highest mean (M = .50, SD = 1.05)

Maternal biological conditionIn the second general linear model, maternal socioeconomic resources accounts for 11.6% of the variance in maternal biological condition. In fact, across all regions, increasing maternal socioeconomic resources contributes toward

Table 2. *Predicting Maternal Socioeconomic Resources.*

Source	df	*F*	*p*	R^2
REGION	4	4983.65	.000	.138
COUNTRY	31	528.31	.000	.116
Model	35	1037.49	.000	.226
Error	124336			
Total	124371			

increased maternal biological condition but not all that powerfully, as indicated by the small, positive standardized regression coefficient for the maternal socioeconomic resources scale (β = .066). The main effect for region is large, with almost 18% of the variance in maternal biological condition explained by systematic differences between regions regarding maternal condition (Table 3).

Although significant, the interaction between maternal socioeconomic resources and region, as well as the interaction between maternal socioeconomic resources and country, are trivial in effect. Maternal socioeconomic resources by region accounts for 0.1% of the variance in maternal biological condition, while the interaction of country with maternal socioeconomic resources accounts for 0.3% of the variance in maternal biological condition. Small interactions such as these merely demonstrate that the effect of maternal resources in explaining maternal biological condition does not vary much – if at all – as a function of regional or country differences but that in this case, some degree of conditional variation by country and region is present for this scale. This trend of trivial explanatory power is evident through almost all of the conditional relationships tested within the sequence of regressions. Moreover, that the main effect for region is so large, in comparison, indicates that almost 18% of the variance in maternal biological condition is explained by systematic differences between regions regarding maternal condition.

What is interesting, on the other hand, is that South Asia (β = -.566) differs from the other three regions in the direction of its coefficient in this regression: Sub-Saharan Africa (β = .097), Latin America/Caribbean (β = .461), and the Near East/ North Africa (β= .768). In fact, Bangladesh ranks the lowest (*M* = -.72 , SD = .85) in maternal biological condition while Turkey has the highest mean (*M* = .82, SD = .94) on that scale. Furthermore, of all the regions, South Asia has the lowest mean maternal biological condition (*M* = -.67, SD = .83) while the Near East/North African region has the highest (*M* = .73, SD = 1.0).

Table 3. *Predicting Maternal Biological Condition*

Source	df	*F*	*p*	R^2
MSR	1	15391.32	.000	.110
REGION	4	6697.18	.000	.177
COUNTRY	31	44.00	.000	.011
REGION *MSR	3	51.53	.000	.001
COUNTRY *MSR	31	10.79	.000	.003
Model	70	629.05	.000	.262
Error	124301			
Total	124371			

Prenatal care for lastborn child

Table 4 reveals that maternal biological condition accounts for 9% of the variance in prenatal care with a small, yet positive, effect (β= .061). Maternal socioeconomic resources has the largest effect (37.1%) in predicting prenatal care for the lastborn child. Indeed, increased maternal socioeconomic resources predicts increased prenatal care (β= .706) across all countries. Region, on the other hand, only predicts 5.5% of prenatal care, while country is the second strongest predictor by explaining 13% of the variance (Table 4). Here it

Table 4. *Predicting Prenatal Care for Lastborn Child.*

Source	df	*F*	*p*	R^2
MBC	1	12222.63	.000	.090
MSR	1	73307.83	.000	.371
REGION	4	1802.21	.000	.055
COUNTRY	31	600.21	.000	.130
REGION *MBC	3	2.80	.038	.000
COUNTRY *MBC	31	6.28	.000	.002
REGION *MSR	3	22.18	.000	.001
COUNTRY *MSR	31	92.02	.000	.022
Model	105	1090.17	.000	.479
Error	124266			
Total	124371			

should be noted that the interaction of country with maternal socioeconomic resources represents the largest proportion – with only 2.2% predictive power – of all the interactions in the entire set of regressions for the interaction model, thereby demonstrating their minimal explanatory contribution overall. Hence, 2.2% of the variance in prenatal care is explained by maternal socioeconomic resources varying as a function of country differences.

Nonetheless, in its entirety, the model testing the effects of maternal condition, resources, region, and country captures 47.9% of the variance in prenatal care for the lastborn child. Across the four regions, South Asia has the lowest mean prenatal care for the lastborn child (*M* = -.28, SD = 1.0), while the Latin American/ Caribbean region has the highest mean (*M* = .44, SD = 1.0) across all countries once again. Note, however, that the Near East/North African region is similar (*M* = -.27, SD = 1.0) to South Asia concerning mean levels of prenatal care.

Sex of the lastborn child

The next regression in this series tests for the effect of country, region, maternal socioeconomic resources, maternal biological condition, and prenatal care in predicting the sex of the lastborn child. As Table 5 shows, the overall model accounts for 49.2% of the variance with almost all of the predictive power being explained by region. In fact, maternal socioeconomic resources only accounts for 0.1% of the variance in predicting the sex of the lastborn child while region explains 49.1% of the variance. Yet, MSR has a small, positive effect such that higher levels of resources predict lastborn daughters across all regions (β = .040). Prenatal care is not significant in predicting the sex of the lastborn child. Moreover, maternal biological condition does not contribute any detectable predictive power to the sex of the lastborn child, given that R^2 equals zero for this predictor as well.

Table 5. *Predicting Sex of Lastborn Child.*

Source	df	*F*	*p*	R^2
PCL	1	2.17	.141	.000
MBC	1	11.63	.001	.000
MSR	1	84.31	.000	.001
REGION	4	30004.76	.000	.491
COUNTRY	31	1.33	.103	.000
REGION* PCL	3	.75	.521	.000
COUNTRY *PCL	31	1.23	.179	.000
REGION* MBC	3	5.62	.001	.000
COUNTRY *MBC	31	1.76	.006	.000
REGION* MSR	3	.93	.424	.000
COUNTRY *MSR	31	.99	.479	.000
Model	140	859.31	.000	.492
Error	124231			
Total	124371			

Health-seeking for lastborn child

The final regression in this series examines the effect of region, country, the three scales, and the sex of the lastborn child in determining health-seeking for that child (Table 6) . Results show that, overall, male lastborn children are more likely to receive treatment and immunizations; however, this effect is very small both in explanatory power (R^2 = 0.1%) and magnitude (β = -.050). The largest contribution (16.7%) in predicting health-seeking across all four regions lies in prenatal care for the lastborn child (β = .041), suggesting that higher rates of prenatal care for the mother predict higher rates of health-seeking for the lastborn child. Furthermore, maternal biological condition has a small, yet significant, positive predictive effect (β = .233) in explaining 4.2% of the variance in health-seeking behaviors. Maternal socioeconomic resources account for only 1.1% of the variance in health-seeking (β = .254); such that, as resources increase, health-seeking for the lastborn child increases. Region accounts for 0.8% of the variance in health-seeking whereby the second strongest predictor is country, accounting for 7.2% of the variance.

Note also that the conditional relationships between prenatal care with region (1.6%) and prenatal care with country (1.7%) are significant, albeit also small, indicating that a small proportion of explanatory power in predicting health-seeking is contingent upon variations in how country- and region-specific differences determine prenatal care. Conditional relationships between maternal biological condition and maternal socioeconomic resources with country and region are even smaller (ranging from 0.1 to 0.5%). Furthermore, conditional relationships between sex of the lastborn child with prenatal care, maternal biological condition, maternal socioeconomic resources, region, and country were either nonsignificant or trivially small in predicting health-seeking for the lastborn child. As such, the entire model accounts for 27.9% of the variance in health-seeking for the lastborn child. What is more, South Asia has the lowest average level of investment in health-seeking behaviors (*M* = -.19, SD = 1.05) whereas mothers within the Near East/North African region (M = .30, SD = .85) demonstrate, on average, higher levels of preventative behaviors toward their lastborn children.

Table 6. *Predicting Health-seeking for Lastborn Child*				
Source	df	*F*	*p*	R^2
SEX	1	68.45	.000	.001
PCL	1	24943.67	.000	.167
MBC	1	5378.30	.000	.042
MSR	1	1428.27	.000	.011
MBC*SEX	1	.03	.872	.000
MSR*SEX	1	.51	.475	.000
REGION	4	257.06	.000	.008
COUNTRY	31	308.99	.000	.072
REGION* SEX	3	14.82	.000	.000
COUNTRY* SEX	31	1.76	.006	.000
REGION* PCL	3	689.04	.000	.016
COUNTRY* PCL	31	68.47	.000	.017
REGION* MBC	3	66.96	.000	.002
COUNTRY* MBC	31	5.30	.000	.001
REGION* MSR	3	48.36	.000	.001
COUNTRY* MSR	31	20.06	.000	.005
REGION* PCL* SEX	3	2.73	.042	.000
COUNTRY* PCL* SEX	31	1.15	.258	.000
REGION* MBC*SEX	3	1.54	.202	.000
COUNTRY* MBC*SEX	31	1.08	.347	.000
REGION* MSR* SEX	3	.32	.813	.000
COUNTRY* MSR*SEX	31	.77	.811	.000
Model	280	171.27	.000	.279
Error	124231			
Total	124371			

DISCUSSION

Region and country predicted nearly 25% of the variability in maternal socioeconomic resources (MSR) and were significant predictors in each successive general linear model. That there are differences in resources across regions and countries is unsurprising, and the amount of variance that region and country accounted for in each GLM ranged from less than 10% for HSL to nearly 50% for sex of the lastborn child.

MSR predicted 11% of maternal biological condition (MBC), which in turn accounted for 9% of prenatal care for the lastborn child (PCL). Neither MSR, MBC or PCL had any meaningful explanatory power for sex of the lastborn child. Health-seeking for the lastborn child (HSL), however, was predicted by PCL, MBC, and to a lesser extent, by MSR and SEX of the lastborn child. Interactions with region and country were generally small, indicating that the main effects of the predictor variables are relatively stable across geographic areas. The exceptions were regarding health-seeking behavior, whether prenatally or after birth. Namely, MSR*country accounted for 2.2% of the variance in PCL, and PCL*region and PCL*country accounted for 1.6% and 1.7% of the variance in HSL respectively. Essentially, women who can obtain healthcare are doing so at differential rates by country and region.

Across the 35 countries there are two small effects that provide minimal support for the TW hypothesis. That is, MSR has a small, positive effect such that higher levels of resources predict lastborn daughters across all regions. Furthermore, male lastborn children are more likely to receive treatment and immunizations. Both are small effects, each accounting for 0.1% of the variance in the analyses. However, the role of polygyny and minimal parental investment by males is central to the assumptions of the theory, and this condition may be differentially met within the four regions. And, in fact, interaction terms for HSL by region and country account for .8% and 7.2% of the variance, respectively. Note, however, that the lack of conditional relationships between sex of the lastborn child and prenatal care, maternal biological condition, maternal socioeconomic resources, region, and country in predicting health-seeking limit any additional support for the TW hypothesis.

As well-established by previous research, males are born at a higher frequency, with the average sex ratio in humans estimated to be 1.06 males born for every female (Cartwright 2000). However, variations across countries exist and a comparison of the current sample sex ratio with national estimates thereof, yielded three evident patterns: one where there is a drop in the number of males but they continue to outnumber females; one where males decrease so drastically within the first five years of life, that the sex ratio becomes female-biased; and one where males initially predominate in number and increase, due to what can only be attributed to a loss of females. The observation that good condition mothers in male-biased countries show a tendency toward producing daughters and that there are not enough daughters in these regions to account for this pattern, is an important point of contrast.

All things considered, though, while the descriptive characteristics initially presented confirm foreseeable demographic differences, the system of regressions used in this research places those differences and similarities into perspective regarding an evolutionary framework as provided by the TW hypothesis. Namely, the fact that Sub-Saharan Africa deviates somewhat from the pattern found for the other three regions is potentially explained by the higher degree of polygyny, on average, across those countries. That is, polygyny may afford more autonomy to wives than monogamy does and the husband's influence is even more denounced the higher the women's education is (Dodoo 1998). Indeed, there is substantial variation in the degree of polygyny across these countries. According to DHS+ information, almost 51% of women in Burkina Faso report having two or more co-wives present and 46% of women from Senegal report having one other wife present. In contrast, 96% of women in Madagascar are not in a polygynous union and the same for 75% of women in Comoros. Furthermore, of those 25% who have a co-wife, 71% only had one co-wife, according to another study (Althaus 1997).

It would seem that polygyny can leave almost half of its male population without a mate. As such, the trend for the African countries in this data would suggest a mild Trivers-Willard effect in that if mothers have the resources, they produce sons. Otherwise, even when in good physical condition, they invest in the production of daughters. Note, however, that the effect for the resources was somewhat greater than that of the effect for physical condition. As such, this is the closest this analysis seems to come in supporting the TW hypothesis across thirty-five countries.

Anderson and Crawford (1993) as well as Carranza (2002) provide critical reviews of how predictions stemming from the TW hypothesis require modification in order to be appropriately applied to humans. Freese and Powell (1999) did not find support for the TW hypothesis in humans either, i.e., no sex-biased differences in socioeconomic investment, but failed to mention paternal care as a potential confound. They conclude with: "...the evidentiary burden would now seem to fall upon those who might attribute our findings to the exceptional character of American society rather than to the more fundamental limitations of the theory" (p. 1737), citing sociologists' "professional obligation... to test [sociobiological] hypotheses fairly and rigorously" (p. 1738). It is hoped that was accomplished here.

However, this research used self-report data and, as such, is prone to typical biases and errors common to such methodologies. For example, standardization, whether in technique or measurement, limits the possibilities of responses and can create demand characteristics. While selection of the lastborn child may capitalize on enhanced memory recall, a focus on the oldest child might serve as a better source for measuring parental investment. In addition, previous studies on birth order indicate that selection of the lastborn child may be confounded by the possibility that the favored child is being studied (Rohde et al. 2003). While no noticeable sex-biased differences were apparent across diarrhea treatment-seeking behaviors, this could in fact be due to reporting error alone. In addition, particularly relevant information concerning polygynous pairings was missing from the data at hand. Finally, definitions of parenting can vary across both monogamous social structures and in settings where alloparenting is normative.

These analyses would have been more informative if child nutritional status as a measure of parental investment were included, along with indicators of maternal condition at preconception rather than postnatally. Analysis of reproductive success of offspring would also enable a more representative test of the original theory. It would also be interesting to test the sex ratio against expected averages at the primary and secondary levels; namely, 3 months post-conception (1.2:1) vs. at birth (1.06:1) sex ratios (from Cartwright 2000) to examine the juncture at which sex ratio manipulation might be occurring.

The foremost issue is the notion of condition – what exactly did Trivers and Willard mean, and why have so many different interpretations been applied to it? If they meant weight and body size for polygynous animals where parental care is trivial, then the theory can be tested on those species and probably should not be expected to fit others. Which is to say, with so many constraints involved in terms of "well-defined conditions" (Trivers and Willard 1973, p. 90) is it really that surprising that there is so much variation not only in the results that have been revealed across species but in the extent to which this theory has been applied?

To the extent that other studies recommend that a true analysis of the TW hypothesis would have to test for whether maternal condition predicts offspring reproductive success and then examine the variance of reproductive success between siblings, it is slightly odd that more studies have not actually done this; that is to say, on species where reproductive success can be tracked. To test for sex of offspring alone, in the absence of the predicted covariates, may actually omit parts of the theory.

Ultimately, there is something inherently poetic in the original theory of Trivers and Willard. That is, the idea that maternal effects are retained from development into adulthood is reminiscent of a comment by the poet Rainer Maria Rilke: "Perhaps we are our childhood still, for as St. Augustine said, 'Whither should it have gone?" Yet, at the end of the day, the specific relevance of the Trivers and Willard hypothesis to humans may be, after all, just another storm in a teacup and better relegated to species that satisfy most, if not all, of the assumptions laid out in the original paper.

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Appendix Table 1. *Final sample size by region and country.*

		Year of collection	Unweighted	Weighted (by sample weight)
South Asia	Bangladesh	1997	3,730	3,505
	India	1998	21,839	21,487
	Nepal	1996	3,246	3,292
			Total = 28,815	Total = 28,284
Sub-Saharan Africa	Benin	1996	2,037	2,037
	Burkina Faso	1993	2,887	1,831
	Cameroon	1998	1,411	1,411
	Central African Republic	1995	1,967	1,967
	Chad	1996	3,789	3,789
	Comoros	1996	732	732
	Cote d'Ivoire	1994	3,025	3,025
	Ghana	1998	1,467	1,356
	Kenya	1998	2,474	2,386
	Madagascar	1997	2,510	2,431
	Malawi	1992	2,230	1,953
	Mali	1996	3,933	3,619
	Mozambique	1997	2,539	2,218
	Namibia	1992	1,750	1,543
	Niger	1998	3,443	3,762
	Senegal	1997	2,615	2,615
	Tanzania	1996	3,518	3,820
	Togo	1998	3,076	3,249
	Uganda	1995	3,290	3,079
	Zambia	1996	3,834	3,827
	Zimbabwe	1994	1,860	1,997
			Total = 54,387	Total = 52,647
Latin America & Caribbean	Bolivia	1998	3,073	2,874
	Brazil	1996	3,034	2,873
	Columbia	1995	3,368	3,517
	Dominican Republic	1996	2,211	1,890
	Guatemala	1995	5,361	5,471
	Haiti	1995	1,805	1,805
	Nicaragua	1998	4,728	5,137
	Peru	1996	10,741	9,960
			Total = 34,321	Total = 33,527
Near East & North Africa	Egypt	1995	5,049	4,371
	Morocco	1992	3,116	3,116
	Turkey	1993	2,351	2,426
			Total = 10,516	Total = 9,913

Appendix Table 2. *List of variables used in scales.*

Scale name & code		Description of variables & coding scheme
Maternal Socioeconomic Resources (MSR)	*	Whether woman lives in urban or rural residence rural=0, urban=1
	*	Household economic status destitute=0, poor=1, middle=2, rich=3
	*	Woman's years of education
	*	Male partner's educational value measured in years if partner present, otherwise equals 0 if no male partner present or if male partner has 0 years of education
Maternal Biological Condition (MBC)	*	Woman's body mass index (BMI) weight in kg/square of height in meters
	*	Whether woman is malnourished, healthy, or overweigth malnourished=0, healthy=1, overweight=2
	*	Duration of current pregnancy (if pregnant) not pregnant=0, otherwise recorded as months (max=10)
	*	Whether woman is currently breast-feeding not breast-feeding=0, currently breast-feeding=1 note: reverse-coded for predicted negative effect
Prenatal Care for Lastborn Child (PCL)	*	Whether woman received prenatal care & type of care did not receive prenatal care=0, received prenatal care but not from medically trained person=1, received prenatal care from medically trained person=2
	*	Number of prenatal care visits no visits=0, otherwise equals number of visits recorded
	*	Whether delivery was assisted & type of assistance delivery was not assisted=0, delivery was assisted=1, delivery was assisted by medically trained person2
	*	Whether delivery took place at a medical facility delivery not at medical facility=0, delivery at medical facility=1
Health-seeking for Lastborn Child (HSL)	*	Child's diarrhea in last 2 weeks child had diarrhea and was not treated=0, no diarrhea=1, had diarrhea and was treated=2
	*	Whether child received BCG vaccination no=0, yes=1
	*	Whether child received measles vaccination no=0, yes=1
	*	Total number of DPT vaccinations ranges from none=0 to max=3
	*	Total number of polio vaccinations ranges from none=0 to max=3
	*	Percent of age-recommended vaccinations child received ranges from 0 to 100

Appendix Table 3. *Sex ratios by region and country.*

		National est. sex ratio (at birth)	Current sample (last-born child <5 yrs)
South Asia	Bangladesh	1.06	1.04
	India	1.05	1.12
	Nepal*	1.05	1.07
Sub-Saharan Africa	Benin	1.03	1.02
	Burkina Faso	1.03	1.03
	Cameroon	1.03	1.04
	Central African Republic	1.03	1.02
	Chad	1.04	0.99
	Comoros	1.03	1.11
	Cote d'Ivoire	1.03	1.02
	Ghana	1.03	0.99
	Kenya	1.03	0.99
	Madagascar	1.03	1.03
	Malawi	1.03	0.99
	Mali	1.03	0.95
	Mozambique	1.03	0.97
	Namibia	1.03	0.99
	Niger	1.03	1.09
	Senegal	1.03	0.95
	Tanzania	1.03	1.03
	Togo	1.03	0.99
	Uganda	1.03	0.93
	Zambia	1.03	0.97
	Zimbabwe	1.03	0.97
Latin America & Caribbean	Bolivia	1.05	1.02
	Brazil	1.05	1.00
	Columbia	1.03	1.05
	Dominican Republic	1.05	1.05
	Guatemala	1.05	1.02
	Haiti	1.05	1.07
	Nicaragua	1.05	0.98
	Peru	1.05	1.03
Near East & North Africa	Egypt	1.05	1.11
	Morocco	1.05	1.11
	Turkey	1.05	1.14

* Indicates the only country where female infant mortality exceeds male infant mortality (72.27 deaths/ 1,000 live births to 68.95 deaths/1,000 live births). Note: Information for sex ratios based on 2003 estimates posted at CIA website for "Worldbook of Facts."