Cross-Cultural Research

http://ccr.sagepub.com

Influences on Women's Reproductive Lives: Unexpected Ecological Underpinnings

Bobbi S. Low, Ashley Hazel, Nicholas Parker and Kathleen B. Welch

Cross-Cultural Research 2008; 42; 201 originally published online May 1, 2008;
DOI: 10.1177/1069397108317669

The online version of this article can be found at:
http://ccr.sagepub.com/cgi/content/abstract/42/3/201

Published by:
SAGE Publications
http://www.sagepublications.com

On behalf of:
Society for Cross-Cultural Research

Cross-Cultural Research
Volume 42 Number 3
August 2008 201-219

10.1177/1069397108317669
http://ccr.sagepub.com
hosted at
http://online.sagepub.com

Influences on Women's Reproductive Lives

Unexpected Ecological Underpinnings

Bobbi S. Low
Ashley Hazel
Nicholas Parker
Kathleen B. Welch
University of Michigan

Modern women's reproductive lives vary considerably, in a patterned fashion. Although cultural factors are important, across societies—even across species—there exist strong patterns predicted by life history theory. For example, the shorter life expectancy e_0 is at birth, the earlier it pays in biological terms to reproduce. Few factors analyzed in women's life patterns in more than 170 nations influence the divergence. Studies on other species assume that (a) the variation is species specific and (b) the conditions are at equilibrium; the relationship between life expectancy and age at first birth is strong, but varies across populations, and is frequently not at equilibrium. Human patterns, like those of other species, may have ecological or life history underpinnings. The answers we find may have policy implications for women's lives and fertility.

***Keywords*:** *life history; demography; fertility; development*

Cross-culturally and across time, women's lives—their reproductive costs and benefits—vary. These differences are patterned rather than random (e.g., Low, 2005a, 2005b, 2007) and produced by the interplay of natural selection imposed by ecological conditions and cultural constraints. In early biological models attempting to reflect ecological influences on fertility, the cost of succeeding (and thus the per capita cost of producing successful offspring) was only influenced by conspecific density; this is clearly too

Authors' Note: Please address correspondence to Bobbi S. Low, Dana Building G142a, Ann Arbor, MI, 48109-1041; e-mail: bobbilow@umich.edu.

simple an explanation for the variation we see in human reproductive and offspring investment patterns.

Compared with women in traditional societies, women in developed nations today are more autonomous with regard to their abilities to choose mates and choose or reject childbearing, hold roles that converge with "traditional" men's roles, and so forth. In many traditional societies, marriages are not matters of simple attraction between potential mates but are largely arranged by relatives (e.g., Low, 1990; Whyte, 1979). The majority of traditional societies for which we have data are, of course, polygynous and patrilocal (e.g., reviews in Low, 2000b, 2007; Murdock, 1957, 1967, 1981; Murdock & White, 1969). In such societies, typically the bride's and groom's fathers and male relatives have considerable influence in arrangements. These patterns have shifted in much of the modern world; women in modern nation-state societies face novel pressures and constraints—costs and benefits that affect women's fertility and give rise to the broad shifts in fertility that we call demographic transitions.

Many nations have gone through demographic transitions to smaller family sizes. The demographic transition, a period when family sizes fell from, for example, 8–10 to 2–3 in western Europe and parts of North America, is something of an evolutionary conundrum (Borgerhoff Mulder, 1998; Low, 2000a, 2000b). It makes some evolutionary and ecological sense that, as competition to get established and marry increases (as in 19th-century Europe and North America and in many developing nations today), higher per capita investment would be advantageous: the cost of children would rise and family size would fall. Mace (1998, 2000a, 2000b) has modeled the evolution of human reproductive rates when wealth is inherited and has shown that cost of children has a large effect. As the cost of each successful child increases, not only would family size fall but women might shift strategies from pure reproductive value to a mixture of resource and reproductive value (Kaplan & Lancaster, 2000; Low, 2000b; MacArthur & Wilson, 1967;). Such a strategy typically also delays women's age at first birth (AFB) as women stay in school longer and then enter and remain in the work force as part of their resource-acquisition strategy. Knodel, Havanon, and Sittitrai (1990) have illustrated the importance of market factors (and the resulting importance of costly schooling) for modern Thailand; Kaplan, Lancaster, Johnson, and Bock (1995) have done similar work in a North American population. Women's shifting strategies in the face of changing market competition and increasing per capita costs of children make selective sense, although some scholars argue that we may have gone too far, in evolutionary terms (Borgerhoff Mulder, 1998; Low, 2000a). That is, when women's resource-acquisition strategies result in no or much delayed and depressed fertility, the strategies are counterselective (e.g., Low, Simon, & Anderson, 2002, 2003).

Today, we see variation in women's educational, marriage, and completed fertility prospects across nations (Low, 2005b). Are these purely cultural, or are there selective aspects to the patterns we see? Historical and cultural pressures have largely taken over from the remnants of earlier, perhaps now defunct, ecological pressures (with exceptions noted below). In modern Western democracies, women typically have free mate choice, may hold political office, and are not restricted from taking up any job. Arranged marriages still exist in some democracies, although the evidence is that they are less common than in previous times (e.g., in India, among some castes). But these conditions are far from universal. Religious influences may retain power that affects women's lives in some societies; in many Muslim societies (particularly the less secular ones), women's dress codes may be severely mandated and women may be subject to clitoridectomy, may not have free mate choice, and may be restrained from daily activities we think of as common, such as voting or driving a car.

Even as among hunter-gatherers, women today clearly face tradeoffs in expending effort to get resources versus to invest resources into children. These tradeoffs may be exacerbated in modern nation-states. Women today in Western developed nations tend to marry later compared with the traditional societies; most women who marry relatively late, work before (and often after) marriage, increasing their resource base (e.g., Low, 2000a, 2000b, 2005b), which typically decreases their realized fertility but allows increased per capita investment in children. Family sizes in developed nations are relatively small today compared with traditional and historical societies. In developing nations, women typically receive less education, marry earlier, and have larger families than in most developed nations.

These well-known patterns have a number of social correlates; yet, it is worth examining whether the very broad and strong life history pressures that operate in other species (e.g., Harvey & Zammuto, 1985; Roff, 1992, 2002; Stearns, 1992) also influence human life history. Here, we raise a seldom considered ecological correlate that appears to remain important in influencing women's reproductive lives. Some modern patterns appear adaptive: For example, fertility among poor urban Black women and women in ex-Soviet countries is relatively early (e.g., Daly & Wilson, 1997; Geronimus, 1996a, 1996b, 2001; Geronimus, Bound, & Waidmann, 1997; Geronimus, Bound, Waidmann, Hillemeier, & Burns, 1996;) as in many traditional and historical societies (e.g., Hill & Hurtado, 1996). Such women face declines in their health and fecundability and in their support systems as they age. We suspect this is true in a number of developing nations as well.

Here we focus on a life history relationship that is extremely strong across nonhuman mammals: the lower life expectancy (e_0) is at birth, the earlier female reproduction should begin. This is an extraordinarily strong pattern across mammals: Stearns (1992, figure 5.10) plotted data from Harvey and Zammuto (1985) for a range of mammals from chipmunks and voles to warthogs and elephants, demonstrating the truly striking convergence of pattern to theory.

Life histories evolve in response to ecological pressures, and the great variations we see in life history traits, such as life span, AFB or time to maturity, clutch or litter size, degree of iteroparity (repeated reproduction), and sex differences in these traits, are all driven by the selective force of ecological conditions (e.g., Roff, 1992, 2002; Stearns, 1976, 1992).

Culture also influences life histories. What about women's AFB cross-culturally? In other species, biologists typically make two assumptions about these relationships: that they are species typical and that they are at equilibrium rather than changing rapidly. In a species as widespread as humans, in sometimes rapidly changing conditions, and with populations in very divergent habitats and social pressures, we might expect to find that these assumptions are not met. Here, we examine the cross-cultural variation, beginning the search both for ecological influences and interactions among ecological and cultural influences.

Materials and Methods

Most variables used here were acquired from the United Nations Development Programme's 2006 Human Development Report (http://hdr.undp.org/hdr2006/statistics/). Life expectancy at birth is a demographic indicator describing "the number of years a newborn infant would live if prevailing patterns of age-specific mortality rates at the time of birth were to stay the same throughout the child's life" and is thus comparable to such calculations for other species. The GINI coefficient, a measure of income inequality, also comes from the Human Development Report. These and other measures were used in the Human Development Report to derive the Human Development Index (HDI), an attempt to reflect quality of life using more than simple economic indicators. In this ranking, in the 2005 data, nations with stable infrastructures and good medical care and education tend to be in the high ranks (Norway ranks 1st; the United States ranks 8th). In all, 32 of the 33 nations holding rank 3 (*low*) are in Africa.

Data on age-specific fertility (the annual number of births per 1,000 women in a particular age group) come from the United Nations' 2003 World Fertility Report (http://www.un.org/esa/population/publications/worldfertility/World_Fertility_Report). The primary sources of these data were civil registration records and/or surveys and censuses.

Data sets that compile and compare national-level indicators have potential inconsistencies from one country to the next. In particular, data for countries falling at the lower end of the HDI are likely to be less reliable than data collected from those near the top in part due to differences in effectiveness of infrastructure, and sometimes further factors, such as internal conflicts. Some data are missing from HDI indicator sets (e.g., we still lack data on children underweight for age for 35 countries). Results should, therefore, be interpreted with respect to potential data gaps and methodological challenges. Nonetheless, these national-level data sets allow us to explore novel questions about international trends, and we can only expect them to become more reliable in the future.

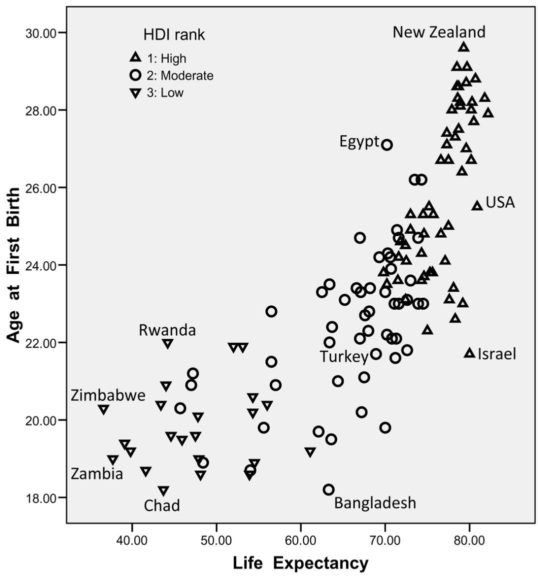
For some variables, multiple sources exist, and the data may not be identical (e.g., the 2003 World Fertility Report compares its estimates of total fertility rate from different years). When multiple-year estimates existed in sources other than the Human Development Report, we chose the year closest to that report (2006); when the Human Development Report and another source reported data for the same variable, for consistency we used the Human Development Report data. Finally, our information about women's lives in modern nation-states typically consists of the national-level aggregate data rather than the deeper ethnographic data we often have for small-scale traditional societies. Nonetheless, we may be able to make some parallel inferences.

Statistical analyses were done using SPSS 14 and JMP 7.0. We explored several relationships for countries ranked as high, moderate, and low HDI, including the relationship between life expectancy at birth and average AFB, and the relative impact of life expectancy on AFB, versus two commonly used social predictors (both included in the Human Development Report), female work-force participation and female schooling.

Results and Discussion

Across nations, women's AFB increases significantly with life expectancy at birth (Figure 1). The overall pattern, that life expectancy and AFB covary, is upheld. However, there is a considerable variation across human populations,

Figure 1
Women's Age at First Birth Increases Nonlinearly With Life Expectancy at Birth (Smoothing Spline Fit, λ = 2,000; R^2 = 0.677)

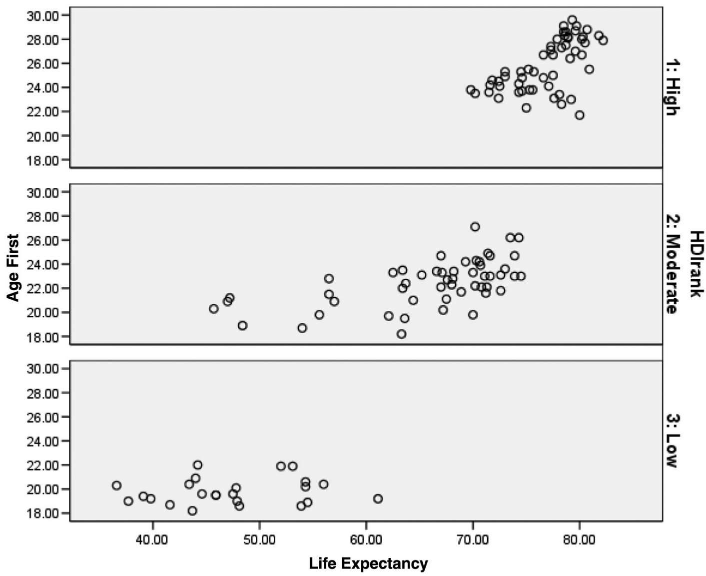


Note: Here, countries are sorted by their Human Development Rank (a complex measure of quality of life) is indicated. It is clear that high, moderate, and low human development countries occupy different parts of the curve. The greatest variation occurs in countries with moderate HDI rank; these are largely the nations that are beginning economic and demographic transitions. The variation in least developed countries (low HDI rank; e.g., Zambia, Zimbabwe, and Chad) and countries with moderate HDI rank suggests that conditions are not in equilibrium. The strong pattern of countries with high HDI rank (Norway, United States, Japan, etc.) suggests a relatively strong relationship between life expectancy and AFB within the most developed nations (see text for further explanation).

suggesting that sociocultural differences, interacting with ecological forces, contribute to the nonlinear pattern we see. Indeed (Figure 2), the pattern for high-ranked countries, all of which have high life expectancies, is almost linear.

Of particular interest are the moderate-ranked countries, which vary greatly in life expectancy. These countries show two clusters (Figure 2): Countries with a life expectancy of 60 years or more tend to show a later

Figure 2
The Patterns of Life Expectancy and Age at First Birth Differ Strikingly for Countries with High, Moderate, and Low HDI Ranks



Note: Note that the high-ranked countries show a strong positive relationship. Moderate-ranked countries cluster into two groups related to life expectancies of ≥60 or <60. The former countries ($n = 43$) show a positive but loose relationship ($\beta = .501$, $p = .001$, $R^2 = 0.251$), and the latter countries show no relationship. So far, we can identify no predictors for low-ranked countries (see text for further explanation).

age of first birth than countries with life expectancy less than 60 years; within each group, influences appear to vary. The significance of the relationship between life expectancy and AFB for countries with moderate HDI rank arises from those countries with life expectancies more than 60 years (Figure 2). Consistent with this, the low-ranked countries, with life expectancies predominantly less than 60 years, show little pattern.

Thus, there appears to be a threshold life expectancy that affects the pattern across countries. The significance of the overall relationship between life expectancy and AFB comes largely from the high slope of the portion of the curve occupied by the developed nations, which have the longest life expectancy (Figures 1 and 2). For countries in which the life expectancy at birth is ≥60 (n = 98), life expectancy is a relatively good predictor of AFB (regression; $\beta = 0.757$, $R^2 = 0.568$, $p < .0001$).

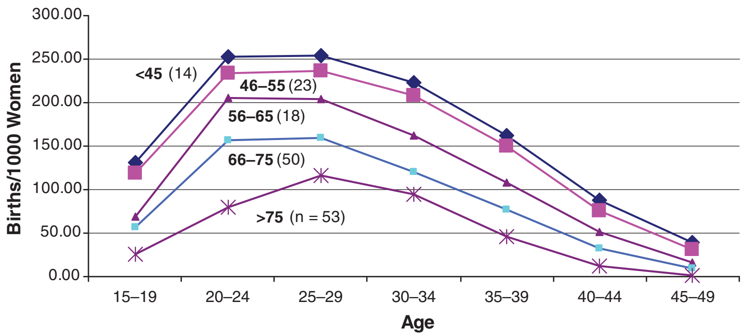
There is no clear relationship between life expectancy and AFB among countries with life expectancies shorter than 60 years (regression; n = 32, $\beta = 0.311$, $R^2 = 0.097$, $p = .083$). All these countries show AFB between 18.2 and 22.8 years ($\bar{x}$ = 20.05 years); this range is similar to those of many traditional and historical societies and may represent real ecological constraints. For the nations with shortest life expectancy, we have yet to find a variable, or combination of variables, that predicts AFB well. In fact, we suspect that conditions in such countries are so volatile (thus, nonequilibrium) that there may be no consistently good predictive variables.

When life expectancy is relatively low, fertility is not only early but remains high at all ages. Figure 3 compares the age-specific fertility of the sample nations grouped by life expectancy. It is clear that women living in nations with shorter life expectancies not only begin having children earlier than others but continue to have high fertility at all ages. Nations are clustered by life expectancy in Figure 3 (<45, 46–55, 56–65, 66–75, >75 years), and each curve completely encloses all curves for nations with higher life expectancies. We suspect this relationship holds at multiple scales; Daly and Wilson (1997) have found similar results (short life expectancy associated with early and high fertility) even at the neighborhood level.

These facts hint at a complex set of relationships between the number of children and the per capita investment required to produce successful children. As noted above, in nonhuman populations, this phenomenon appears to be related to conspecific density (r- and K-selection, MacArthur & Wilson, 1967), which indeed relates to the cost of producing successful competitive offspring. In human populations, the situation is not clearly linked to population density but more often to other factors (e.g., market forces) that may increase the competitive environment for children. Low (2000a, 2000b) has drawn the parallel between r–K selection and demographic transitions.

The 19th-century demographic transition in Europe and North America was once thought to be an inevitable concomitant of industrialization. It now looks, in retrospect, to have been driven in part by the changing resource value of children, in part by the costs of producing competitive children, and in part by highly competitive environments that make women's resource value increase relative to their reproductive value (e.g., see Becker, 1981; Easterlin & Crimmins, 1985; Kaplan & Lancaster, 2000; Knodel et al., 1990; Low, 1992, 2000a, 2000b).

Figure 3
Age-Specific Fertility for the Nations in This Sample, Clustered by Life Expectancy at Birth.



Note: Women in nations with low life expectancy not only have early ages at first birth but continue to have high fertility at all ages (see text for further explanation).

That is, when confronted by highly competitive environments in which only well-invested children can establish themselves, women may begin to delay fertility, seek education, and work more and longer, helping to accumulate familial resources. From a life history perspective, because age-specific fertility and mortality predict the optimum AFB across species (e.g., Stearns, 1992), nations such as New Zealand (Figure 1), in which the average AFB is 29.5 years, have delayed first births well beyond the optimum (cf. Borgerhoff Mulder, 1998; Low 2000a, 2000b; Low et al., 2002, 2003); nonetheless, in developing nations in which life expectancy is sufficient, strategies of delayed reproduction in order to get education or work-related resources may be highly effective (e.g., Knodel et al., 1990).

Life Expectancy and Human Development Rank in Developed and Developing Nations

Figures 1 and 2 highlight striking differences in the relationship between life expectancy and AFB when developed nations and least developed nations are compared. Countries with high HDI ranks show a strong positive relationship between life expectancy and AFB (Figures 1 and 2; Table 1). Although life expectancy at birth clearly is important for countries with high life expectancy in predicting AFB, it is also obviously not the only variable of interest.

Table 1
Life Expectancy at Birth, Women's Work-Force Participation, and Women's Schooling Hold Different Relationships to Women's Age at First Birth in High, Moderate, and Low HDI Countries.

	β, life expectancy (*p*)	β, Female Secondary School Enrollment (*p*)	β, Female Participation in the Work Force (*p*)	R^2
Human Development Index Rank				
High (*n* = 43)	0.544 (.0001)	0.296 (.020)	0.019 (.868)	0.526
Moderate (*n* = 37)	0.250 (.109)	0.336 (.025)	–0.332 (.020)	0.520
Low (*n* = 18)	0.142 (.637)	0.243 (.362)	–0.228 (.446)	0.166
Life expectancy				
≥60 years (*n* = 75)	0.596 (.0001)	0.350 (.0001)	–0.136 (.054)	0.696
<60 years (*n* = 23)	0.403 (.029)	0.463 (.027)	–0.243 (.197)	0.461

Life expectancy has numerous correlates: women's status, presence of health professionals (which reduce infant and maternal mortality, thus raising life expectancy), absence of internal strife and civil war, and absence of various public health measures. Some variables (e.g., proportion of births attended by medical professionals and doctors per 1,000 individuals) have obvious connections to life expectancy, whereas other variables (e.g., female participation in the work force) do not. Because the United Nations' HDI is designed to reflect quality of life, it includes many of these variables. Thus, the high–life expectancy nations also tend to have high HDI rankings (Figure 2).

We are only beginning to tease apart some of the sociocultural influences on AFB and their interactions with the ecologically driven factors. Nonetheless, it is already clear that different influences are most important in the three categories of HDI rank (Table 1).

What Can Outliers Tell Us?

Obviously, numerous factors can cause a mismatch between life expectancy at birth and the predicted AFB. Among the countries with high HDI ranks, for example, Israel is an outlier, with a high and relatively stable life expectancy at birth of 80 years but a relatively young AFB of just less than 22 years (which would be predicted by a much shorter life expectancy e.g., Turkey's). Because these are national-level data, they do not reflect within-country variation, and if fertility patterns vary significantly within a nation (e.g., with ethnicity or religious affiliation), we would not be able to tease those influences apart. It is tempting, also, to speculate about the possible role of perceived threats to life expectancy in shaping people's fertility decisions. We have no actual data for this case, but note that Chisholm, Quinlivan, Petersen, and Coall (2005) and Hill, Ross, and Low (1997) have found that perceived life expectancy influences behavior, from risk-taking (Hill et al., 1997) to reproductive strategies (Chisholm et al., 2005). We simply suggest that examining outliers in this relationship may be informative.

Outliers may also highlight differing influences on fertility. In cross-species comparisons, we noted that two assumptions are made: that the life expectancy–AFB relationship is species typical and that it is at equilibrium. Clearly, the first assumption is belied by the cross-cultural variation in humans (Figure 1). The second assumption, that the reported relationships are at equilibrium, is also not true for humans. Among the countries with moderate HDI ranks, which show great variation, there are several outliers that may prove informative about this assumption.

If we had only current data (as is typical for analyses of other species), we would be puzzled: Chad, with a life expectancy of 43.7 years, has a young AFB (18.3 years). In Chad, life expectancy has remained low for about a generation (it was 45.7 years in 1990; the shift from 1990 to 2005 is only a decrease of 2 years), and we suspect life expectancy and AFB are in equilibrium. Zimbabwe, with a shorter life expectancy than Chad (36.6 years), has AFB of 20.3 years. In Zimbabwe, however, life expectancy has recently and dramatically decreased (from 61.6 years in 1990 to 36.6 years in 2005). Currently, roughly 20% of individuals in the 15- to -49-year age range are infected by the HIV, and the rapid spread of HIV or AIDS is widely thought to have contributed greatly to rapidly decreased life expectancy. It is hardly surprising if life expectancy and AFB are not in equilibrium. South Africa and Namibia, like Zimbabwe, have much later ages at first birth (20.9 years and 21.2 years) than that predicted for their life expectancies (47 years and 47.2 years). Here, too, recent rapid spread of HIV appears to have caused dramatic shifts in life expectancy in the last 15 years; currently, the estimates of HIV in the 15- to 49-year age group are 18.8% (South Africa) and 19.6% (Namibia).

We suggest that rapid historical shifts in conditions that affect life expectancy (war, genocide, and HIV or AIDS) will often result in nonequilibrium conditions and that rapidity of shifts, the scale of shifts (e.g., 5-year change in life expectancy vs. 15-year change), and whether the threshold life expectancy value of roughly 60 years was reached or breached, all matter. We suspect that a lag time exists for predicting AFB from life expectancy effectively (sadly, we have not found reliable historical data on AFB), that life expectancy affects shifts in AFB at life expectancies of about 60 years, and that for countries with life expectancy > 60 years, sociocultural factors will be of increased importance. Further, there is a strong possibility that in such a long-lived species, the impacts of infant mortality versus young adult mortality might differ. We recognize that e_0 is an aggregate measure and humans are extraordinarily long lived (e.g., Low, 2000b, chap. 6). Age-specific mortality may provide a more predictive measure. For example, high mortality of individuals younger than 5 years (due to poor health vulnerabilities to disease) should have a larger effect on AFB than high mortality of reproductively aged men (due to death in war or other types of conflict). We begin exploring this idea in a follow-up article due out next year.

Finally, nonlinear impacts are likely if life expectancy is low because conditions are truly dire or women simply may become subfecund, with low and late fertility. In the countries with low HDI ranks, many of the described conditions are clearly stressful. Stress can alter physiological profiles (e.g., Ranjit, Young, & Kaplan, 2005) and reduce fecundability (e.g., Flinn 1999; Nepomnaschy et al., 2006); its effects may be nonlinear (e.g., Ellis, 2004). Certainly in countries with the lowest HDI rankings (32/33 of which are African), multiple factors are likely to affect women's reproduction, and we should not be surprised if no simple pattern emerges.

Interactions

A country's position on the curve in Figure 1 is obviously related to that country's HDI (the United Nations' measure reflecting quality of life as suggested by health and economic variables). Life expectancy at birth is counted among many other variables in computing the HDI rank. However, the spread of countries with moderate HDI ranks (Figure 2) suggests that life expectancy itself may exert an independent influence. Countries with a life expectancy at birth of less than 60 years show no AFB greater than ~23 years (and these, as we note, are outliers in which life expectancy has declined greatly in the past 15 years).

It seems likely, in addition, that there may be interactions among more ecologically influenced variables (e.g., life expectancy) and sociocultural variables such as women's secondary school enrollment and women's work force participation. These last two variables have frequently been suggested as influencing age-specific fertility. The relative predictive power of life expectancy, female secondary school enrollment, and women's work force participation varies with the HDI rank and with high (≥60 years) versus low (<60 years) life expectancy. This suggests that (a) life expectancy is most important in countries with high HDI ranks and long life expectancy and (b) there are important interactions to explore. Among the 43 countries with high HDI ranks in this sample with all required data, life expectancy (p = .0001) contributes considerably more to predicting AFB than either female secondary school enrollment (p = .02) or female work force participation (p = .868; Table 1).

When countries with moderate HDI ranks (n = 37) are examined, life expectancy has only a marginal predictive power (p = .109), female secondary enrollment remains a predictor (p = .025), and female work force participation gains predictive power (p = .02; Table 1). We suspect that these results reflect interactions among multiple factors. Among nations (n = 18) of low HDI rank, none of the three independent variables has even marginal impact, reflecting, perhaps, the array of negative forces from HIV to civil war and displacement.

The role of female work force participation is interesting. It is significant in midranked countries but, perhaps unexpectedly, its sign is negative. That is, as women participate more in the work force, AFB declines. We speculate that this reflects the difference in women's work in industrialized nations, where women typically hold jobs that conflict with child care duties, versus women's work in developing nations, which can include market profit from home-centered activities such as small-scale agriculture, weaving, and so forth.

Not surprisingly, the pattern for countries with life expectancy greater than or equal to 60 years (n = 75) is similar; life expectancy remains important in predicting AFB. Female secondary school enrollment, however, is equally important (Table 1), and female work force participation is marginally significant. These changes are generated by the addition of midranking HDI countries with life expectancies greater than or equal to 60 years. Note that the influence of female work on AFB is negative. The variation within countries given a moderate HDI rank suggests that the important factors in shifting AFB may vary across countries and as-yet-unexplored variables may interact.

Unintended Impacts of Policies on Women's Lives

Because many social and biological variables are interrelated and because the relationships can be complex, we must also be alert that well-meant policies do not generate unintended impacts. Policies aimed at changing population dynamics can have unintended, even perverse, effects (e.g., Anderson, 2004).

Further, policies not intended to affect population can also affect women's fertility and mortality and their infants' survival—the very heart of demographic shifts. There has been a great deal of discussion of the People's Republic of China's One-Child Policy as it has affected women's fertility. Yet the impacts of the One-Child Policy were trivial compared with the preceding half-century of rules not aimed in any way at fertility (Ting, 2004a, 2004b). From the transition to socialism through the Cultural Revolution's two phases, and the rest-and-recuperation period, fertility and mortality were hugely affected in at least three major Chinese provinces (Shaghai, Shaanxi, and Hebei) analyzed by Ting. In fact, the only ecological phenomenon to affect mortality discernibly on the scale of Mao's impacts was a major earthquake in Hebei.

Similarly, among the impacts of the Soviet Union's collapse was the termination of forestry subsidies in the peninsula of Kamchatka (Hitztaler, 2004a, 2004b). This failure—not even a policy—was certainly not aimed at either fertility or mortality. Nonetheless, because Kamchatka was a destination for many young workers during the subsidy period (one could accumulate enough money in a few years for, example, an apartment in Moscow), the Kamchatkan population was young and its demography was strongly affected by the collapse. The collapse of subsidized forestry led, in Kamchatka, to greatly declined age-specific fertility, to increased out-migration, and in some cases to increased mortality. Interestingly, the pace and scale of the impacts varied with local ecological conditions and the distribution of particular plant communities; even in modern conditions, there may be both ecological and sociocultural impacts.

Smaller scale examples of unexpected (and arguably perverse) impacts include the thrusts to combat female-preferential infanticide. It may seem only logical that improving women's education and employment would improve the status of women and result in better treatment of women and of female infants. But this argument may be stated too generally and fail to consider secondary effects. Recent demographic reports from India, China, and Korea suggest that when women's status improves, preferential allocation of resources to sons may also increase—the opposite of the desired outcome (Das Gupta & Visaria, 1996). In at least some areas, education of women correlates positively with female infanticide (Das Gupta, 1987; Das Gupta & Visaria, 1996) rather than reducing it. It is not at all clear that raising women's status will protect female infants; discrimination against daughters may actually increase with women's status in these countries (Anderson & Romani, 1977; Anderson, Kim, & Romani, 1997; Das Gupta & Visaria, 1996).

Conclusion: Applications for Policies Affecting Women's Reproductive Lives Today

Part of our point here is that measures such as HDI are often good descriptors, but they are complex compound measures incorporating both correlated and uncorrelated independent variables. If we can isolate particular components that strongly affect life expectancy and AFB, we have a clearer idea of what relatively easily influenced variables might be the focus of policy interventions to increase life expectancy and AFB.

If we can identify easily-influenced variables, we may have fertility-reducing policy options to explore. Some social indicators of concern to policy makers (e.g., levels of infant and maternal mortality, proportion of births attended by professionals) might be expected to have clear and direct relationships to life expectancy and AFB. For other measures (e.g., level of female secondary school enrollment, female work force participation), there is no clear link—yet they may help shape women's age at first reproduction in social ways. As we noted above, because overt fertility policies can be controversial, if we begin to understand how social phenomena affect core biological relationships, perhaps we can hope to craft acceptable and more effective policies. Of course, partly because these partial correlations exist and because the particular impacts in individual countries vary, we are under no illusions that any panaceas exist.

The examples in the preceding section suggest that we could profitably take a broader look at policies not explicitly aimed at affecting fertility or population growth or decline. We already know that education and women's participation in the workforce show patterns in some conditions with women's fertility. But the simple and strong relationships between life expectancy at birth and fertility timing and total fertility—particularly for nations with higher life expectancies—suggest that we might profitably aim for policies that improve health and life expectancy because not only do they have primary salutary effects on quality of life but they may, at some point, lead to later ages at first birth and reduced population growth rates.

In the developing world today, there are very basic ecological phenomena that affect life expectancy and possibly women's ages at first birth and total fertility. Across nations, when life expectancy is low, early reproduction is the response. Policies that increase access to health professionals during pregnancy, of course, should begin to affect reproductive patterns. But even simpler cheaper approaches may be helpful. We may see fertility responses to approaches that result in better access to clean water and other public health issues. We offer two caveats, however. First, we can see that there are countries in which life expectancy is shifting rapidly; such nonequilibrium conditions may not lead to predicted changes in AFB. Second, appropriate measures will vary in nations with high, moderate, and low HDI ranks, and the nations most in need will also be those for which it will be most difficult to find strategies to simultaneously improve the quality of life, increase life expectancy, and delay the age of first reproduction.

References

Anderson, B. (2004). Unintended population consequences of policies. *Population and Environment, 25*(4), 377–390.

Anderson, B. A., Kim, D., & Romani, J. H. (1997). *Health personnel, son preference and infant mortality in China* (Res. Rep. No. 97-409. Ann Arbor: Population Studies Center, University of Michigan.

Anderson, B. A., & Romani, J. H. (1977). *Socioeconomic characteristics and excess female infant mortality in Jilin province, China* (Res. Rep. No. 97-409). Ann Arbor: Population Studies Center, University of Michigan.

Becker, G. (1981). *A treatise on the family.* Cambridge, MA: Harvard University Press.

Borgerhoff Mulder, M. (1998). The demographic transition: Are we any closer to an evolutionary explanation? *Trends in Ecology and Evolution, 13*, 266–270.

Chisholm, J. S., Quinlivan, J. A., Petersen, R. W., & Coall, D. A. (2005). Early stress predicts age at menarche and first birth, adult attachment, and expected lifespan. *Human Nature 16*(3), 233–265.

Daly, M., & Wilson, M. (1997). Life expectancy, economic inequality, homicide, and reproductive timing in Chicago neighborhoods. *British Journal of Medicine, 314*, 1271–1274.

Das Gupta, M. (1987). Selective discrimination against female children in rural Punjab, India. *Population and Development Review, 13*(1), 77–100.

Das Gupta, M., & Visaria, L. (1996). Son preference and excess female mortality in India's demographic transition. In *Sex preference for children and gender discrimination in Asia, Korea Institute for Health and Social Affairs* (KIHASA), Seoul, Korea: KIHASA.

Easterlin, R., & Crimmins, E. (1985). *The fertility revolution: A supply-demand analysis*. Chicago: University of Chicago Press.

Ellis, B. J. (2004). Timing of pubertal maturation in girls: An integrated life history approach. *Psychological Bulletin, 130*, 920–958.

Flinn, M. V. (1999). Family environment, stress, and health during childhood. In C. Panter-Brick & C. Worthman (Eds.), *Hormones, health, and behavior* (pp. 105–138). Cambridge: Cambridge University Press.

Geronimus, A. T. (1996a). Black/white differences in the relationship of maternal age to birthweight: A population-based test of the weathering hypothesis. *Social Science & Medicine, 42*(4), 589–597.

Geronimus, A. T. (1996b). What teen mothers know. *Human Nature, 7*(4), 323–352.

Geronimus, A. T. (2001). Inequality in life expectancy, functional status, and active life expectancy across selected Black and White populations in the United States. *Demography, 38*(2), 227–251.

Geronimus, A. T., Bound, J., & Waidmann, T. A. (1997). *Health inequality, family caretaking systems, and population variation in fertility-timing.* Paper presented at the annual meeting of the Population Association of America, Washington, DC.

Geronimus, A. T., Bound, J., Waidmann, T. A., Hillemeier, M. M., & Burns, P. B. (1996). Excess mortality among Blacks and Whites in the United States. *New England Journal of Medicine, 335*, 1552–1558.

Harvey, P., & Zammuto, R. M. (1985). Patterns of mortality and age at first reproduction in natural populations of mammals. *Nature, 315*, 319–320.

Hill, E. M., Ross, L. T., & Low, B. (1997). The role of future unpredictability in human risk-taking. *Human Nature, 8*(4), 287–325.

Hill, K., & Hurtado, A. M. (1996). *Ache life history: The ecology and demography of a foraging people.* New York: Aldine de Gruyter.

Hitztaler, S. (2004a). Changing human populations in post-Soviet Kamchatka: An integrated study of shifts in fertility and net population. *Population and Environment, 25*(4), 335–354.

Hitztaler, S. (2004b). The relationship between resources and human migration in central Kamchatka during the post-Soviet period. *Population and Environment, 25*(4), 355–375.

Kaplan, H., & Lancaster, J. (2000). The evolutionary economics and psychology of the demographic transition to smaller families. In L. Cronk, N. Chagnon, & W. Irons (Eds.), *Adaptation and human behavior: An anthropological perspective* (pp. 283–322). New York: Aldine de Gruyter.

Kaplan, H., Lancaster, J. B., Johnson, S. E., & Bock, J. A. (1995). Fertility and fitness among Albuquerque men: A competitive labour market theory. In R. I. M. Dunbar (Ed.), *Human reproductive decisions: Biological and social perspectives* (pp. 96–136). London: St. Martin's Press.

Knodel, J., Havanon, N., & Sittitrai, W. (1990). Family size and the education of children in the context of rapid fertility decline. *Population and Development Review, 16*(1), 31–62.

Low, B. (2005a). Families: An evolutionary ecological approach. In L. R. Jaipaul & P. G. Uwe (Eds.), Families on global perspective (pp. 14–32). Boston: Allyn & Bacon.

Low, B. (2005b). Women's lives there, here, then, now: A review of women's ecological and demographic constraints cross-culturally. *Evolution and Human Behavior, 26*, 64–87.

Low, B. (2007). Ecological and sociocultural influences on mating and marriage systems. In R. Dunbar & L. Barrett (Eds.), *The oxford handbook of evolutionary psychology* (pp. 449–462). Oxford, England: Oxford University Press.

Low, B. S. (1990). Sex, power, and resources: Ecological and social correlates of sex differences. *International Journal of Contemporary Sociology, 27*(1–2), 49–74.

Low, B. S. (1992). Toward an ecological demography. *Population and Development Review, 18*(1), 1–31.

Low, B. S. (2000a). Sex, wealth, and fertility—Old rules, new environments. In L. Cronk, N. A. Chagnon, & W. G. Irons (Eds.), *Adaptation and human behavior: An anthropological perspective* (pp. 323–344). New York: Aldine de Gruyter.

Low, B. S. (2000b). *Why sex matters: A Darwinian look at human behavior*. Princeton, NJ: Princeton University Press.

Low, B. S., Simon, C. P., & Anderson, K. G. (2002). An evolutionary ecological perspective on demographic transitions: Modeling multiple currencies. *American Journal of Human Biology, 14*, 149–167.

Low, B. S., Simon, C. P., & Anderson, K. G. (2003). The biodemography of modern women: Tradeoffs when resources become limiting. In J. L. Rodgers & H. P. Kohler (Eds.), *The biodemography of human reproduction and fertility* (pp. 105–134). Boston: Kluwer Academic.

MacArthur, R., & Wilson, E. (1967). *The theory of island biogeography*. Princeton, NJ: Princeton University Press.

Mace, R. (1998). The coevolution of human fertility and wealth inheritance strategies. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 353*, 389–397.

Mace, R. (2000a). An adaptive model of human reproductive rate where wealth is inherited. In L. Cronk, N. A. Chagnon, & W. G. Irons (Eds.), *Adaptation and human behavior: An anthropological perspective* (pp. 261–281). Hawthorne, NY: Aldine de Gruyter.

Mace, R. (2000b). Evolutionary ecology of human life history. *Animal Behaviour, 59*, 1–10.

Murdock, G., & White, D. (1969). Standard cross-cultural sample. *Ethnology, 8*, 329–369.

Murdock, G. P. (1957). World ethnographic sample. *American Anthropologist, 59*, 195–220.

Murdock, G. P. (1967). *Ethnographic atlas*. Pittsburgh, PA: University of Pittsburgh Press.

Murdock, G. P. (1981). *Atlas of world cultures*. Pittsburgh, PA: University of Pittsburgh Press.

Nepomnaschy, P. A., Welch, K. B., McConnell, D. S., Low, B. S., Strassmann, B. I., & England, B. G. (2006). Cortisol levels and very early pregnancy loss in humans. *Proceedings of the National Academy of Sciences 103*(10), 3938–3942.

Ranjit, N., Young, E. A., & Kaplan, G. A. (2005). Material hardship alters the diurnal rhythm of salivary cortisol. *International Journal of Epidemiology*, *34*(5), 227–231.

Roff, D. (2002). *Life history evolution*. Sunderland, MA: Sinauer.

Roff, D. A. (1992). *The evolution of life histories: Theory and analysis*. New York: Chapman and Hall.

Stearns, S. C. (1976). Life-history tactics: A review of the ideas. *The Quarterly Review of Biology, 51*, 3–47.

Stearns, S. C. (1992). *The evolution of life histories*. Oxford, England: Oxford University Press.

Ting, T. F. (2004a). Resources, fertility, and parental investment in Mao's China. *Population and Environment, 25*(4), 281–297.

Ting, T. F. (2004b). Shifts in reproductive patterns in China. *Population and Environment, 25*(4), 299–317.

Whyte, M. K. (1979). *The status of women in pre-industrial society*. Princeton, NJ: Princeton University Press.

Bobbi S. Low, BA, PhD, is a professor of resource ecology in the School of Natural Resources and Environment, University of Michigan, and a faculty associate in population studies, Institute of Social Research, and in the Center for Study of Complex Systems, both at the University of Michigan. Her research centers on behavioral ecology and life history theory, including human studies.

Ashley Hazel, BA, MSc**,** is currently a PhD candidate at the School of Natural Resources and Environment and a training fellow in the Interdisciplinary Program in Infectious Disease at the School of Public Health, at the University of Michigan. Her dissertation examines the behavioral ecology and epidemiology of STD among African pastoralists in northern Namibia. She has an MSc in anthropology from University College London and a BA in anthropology and biology from Hunter College, CUNY.

Nicholas Parker, BA, received a degree in economics from Boston College, then worked as a behavioral research assistant for primate projects in Costa Rica and Uganda. A doctoral candidate at the University of Michigan, School of Natural Resources and Environment, he is currently pursuing his dissertation research in environmental governance and international development in the Rufji River Basin, Tanzania.

Kathleen B. Welch, MS, is a senior statistician at the Center for Statistical Consultation and Research, and an adjunct lecturer in the Department of Biostatistics, both at the University of Michigan. Her interests are in models for clustered and longitudinal data, and she has recently coauthored a book, *Linear Mixed Models: A Practical Guide Using Statistical Software*, Chapman Hall, 2007, along with Brady West and Andrzej Galecki.