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Authors: Elizabeth M. Miller

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Author: Elizabeth M. Miller, Department of Anthropology, University of Michigan

Corresponding author: Elizabeth M. Miller, emmill@umich.edu

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Abstract

There is a strong link between maternal knowledge and child well-being in many populations worldwide. Fewer studies have investigated the links between indigenous systems of medical knowledge and infant outcomes in non-Western societies, such as the Ariaal people of northern Kenya. This study has four goals. First, it defines culture-specific domains of health knowledge in Ariaal mothers using the cultural consensus method, a statistical model that measures knowledge shared by a set of informants. Second, it identifies factors that predict maternal health knowledge. Third, it investigates associations between maternal health knowledge and treatment-seeking behaviors. Finally, it associates health knowledge with biomarkers of infant health. Data collection took place in two separate periods. The first data collection period (October-November 2007) enrolled 41 women to participate in an open-ended interview or true-false consensus questionnaire. The second data collection period (November 2008-January 2009) used information from the cultural consensus analysis to assess how health knowledge impacted infant health outcomes and treatment. Women and infants in this data collection period (n = 251 pairs) underwent anthropometric measurement and participated in a questionnaire that included traditional medicine consensus questions. Data were analyzed using the cultural consensus capabilities in ANTHROPAC 4.98; univariate and multivariate statistics were performed in SAS 9.2. This study found consensus in the domains of infant illness, traditional medicine, Western medicine, and treatment decision-making. Proximity to a medical dispensary and use of public health infrastructure significantly predicted higher levels of maternal health knowledge. Mothers' knowledge of traditional medicine was positively associated with treating infants at a dispensary versus at home. Finally, women with greater knowledge of traditional medicine had infants who were significantly less likely to have been ill in the previous month. These results

highlight the importance of both traditional and Western health knowledge for Ariaal mothers and infants.

Introduction

Maternal knowledge of health is intimately associated with child well-being. Multiple studies have found that mothers' years of schooling are associated with improved child health and mortality (Basu & Stephenson, 2005; Caldwell & McDonald, 1982; Caldwell, 1990; Cochrane et al., 1982). For example, there is a strong relationship between maternal education and child nutritional status in Brazil (Frost et al., 2005) and Lesotho (Ruel et al., 1992), and maternal education and infant mortality in Bangladesh (Muhuri, 1995). In addition, higher maternal education predicts increased health care-seeking behaviors in some societies (Desai & Alva, 1998; Elo, 1992). These results are often, but not always, independent of correlated factors such as socioeconomic status, hygiene, husband's education and available health care facilities (Cleland & Van Ginneken, 1988; Desai & Alva, 1998). It is clear that formal maternal education can play a strong role in alleviating infant and child morbidity and mortality, and rightfully plays a prominent role in child-focused public health campaigns (Barrera, 1990). The focus on education as a proxy for maternal knowledge, however, discounts indigenous forms of health knowledge that are integrated in women's culture and society. In addition, it discounts the health knowledge of women who have had little to no formal education.

In contrast to the focus on education level as a proxy for maternal knowledge, recent research among the Tsimane' of Bolivia has attempted to tie indigenous forms of knowledge with child nutritional and health outcomes. McDade et al. (2007) found that Tsimane' mothers' ethnobotanical knowledge has a positive effect on child health outcomes. Tanner et al. (2011) continued this research by finding an association between Tsimane' mothers' ethnobotanical knowledge and a decreased probability of helminth infection in their children.

Although McDade et al. (2007) and Tanner et al. (2011) addressed child health outcomes, infant health differs for several reasons. First, infants are a more sensitive measure of population health and nutrition than children owing to their high levels of mortality and morbidity under severe conditions (Reidpath & Allotey, 2003). Second, infancy is generally a period of intensive maternal care, which strengthens the effect of maternal knowledge on infant health outcomes compared to children's outcomes, whose care may be more distributed throughout communities. Finally, infants are entirely dependent on their parents for health care decisions. Older children have their own knowledge, culture and behavior that may be independent of parental involvement; studying infants eliminates this possibility. Because of this, infant populations are ideal for addressing the association between maternal health knowledge and infant well-being.

This study examined maternal knowledge of health and infant nutritional and health outcomes among Ariaal mothers and infants of northern Kenya. The Ariaal are a group of settled pastoralists who use both medicinal plants and Western medical facilities for health care, but lack basic public health infrastructure in many areas. Most women in this population lack formal schooling but nevertheless make important health care decisions for their infants. This study had four major objectives. First, it developed a cultural consensus model for infant illness and treatment to determine the nature and scope of health knowledge in Ariaal women. Second, it explored how community and individual characteristics predict health knowledge in Ariaal mothers. Third, it examined the association between indigenous maternal health knowledge and treatment-seeking behaviors for sick infants. Fourth, it tested the association between indigenous maternal health knowledge and measures of infant health outcomes in the Ariaal population.

Cultural Consensus

Cultural values and beliefs underpin Ariaal mothers' knowledge of health and helps motivate their treatment decision-making process. Because culture is a collective property and not an individual characteristic, however, it can be difficult to associated cultural variables with outcome measures of health and well-being (Dufour, 2006). Cultural consensus techniques can overcome this hurdle by allowing cultural beliefs to be collectively defined while assessing each individual's knowledge of that set of beliefs. Individual variation in cultural competence can then be associated with health outcomes, integrating biology and culture into the biocultural model (Dufour, 2006).

Cultural consensus is a mathematical model for investigating information about cultural domains and the knowledge of informants within a culture (Romney, 1999; Romney, Weller, & Batchelder, 1986). This analysis is based on the assumption that cultural knowledge can be shared by members of a culture and can be reliably and validly measured. It assumes that the researcher does not know the answers to the questions about each cultural domain and that cultural knowledge may be unequally distributed between individuals. This method allows individuals within the culture to define a cultural domain while assessing individuals' knowledge of the cultural domain. Cultural domains in this study relate to health knowledge: illness concepts, treatment decisions, and Western and traditional medicine.

Field Site

The Ariaal people are a group of settled pastoralists residing in Marsabit District, Kenya (Figure 1). The Ariaal are an ethnic group that is closely tied to the Samburu and Rendille populations of northern Kenya, sharing kinship, cultural, and linguistic elements with both (Fratkin, 1998). In general, the settled pastoralists of this study keep cattle. They supplement

their food resources with varying degrees of subsistence agriculture and market economy; however settlement appears to have brought few to no improvements to Ariaal health and well-being (Fujita, Roth, Nathan, & Fratkin, 2004; Nathan, Fratkin, & Roth, 1996).

The Ariaal are a unique group in which to study knowledge of health and traditional medicine. First, individuals in this population experience poor access to water, high levels of malnutrition, and endemic disease (including diarrheal diseases, respiratory infections, measles outbreaks, malaria, and HIV/AIDS; Fratkin & Roth, 2004), making health care an issue of primary importance to Ariaal people. Second, people have differential access to medical services in the community due to geographical location and cost, possibly rendering disparities in treatment options and health outcomes. Finally, people have more than one treatment option: the Ariaal have traditionally relied on local medicinal plants for treatment as well as more recent Western medical facilities, making realms of health knowledge potentially more diverse. Infants in particular are guaranteed free vaccinations from the Kenyan government so nearly all are presented to Western medical facilities within the first few months of life. Ariaal infants' developing immune system and their exposure to disease-causing weaning foods such as cow milk, corn meal, and potatoes also make them vulnerable to disease. These factors make the study of health and healthcare an important priority in Ariaal communities.

This study took place in the Ariaal villages of Karare, Parkishon, and Kituruni. There are no paved roads, running water, electricity or communications infrastructure in any of the three communities; however each community has its own unique challenges that impact healthcare availability.

Karare is a village along the main road between Marsabit Town and Isiolo located approximately 17 km from Marsabit Town. Karare, one of the larger Ariaal communities, has schools, small shops, churches, and a medical dispensary run by the Catholic Church.

Parkishon is several kilometers closer to Marsabit Town located about 1 km from the main road. It is a more recent community, having just been settled within the past ten years (Adano & Witsenburg, 2008). Parkishon does not have a dispensary and has only recently begun construction on schoolrooms, indicating that the general infrastructure of Parkishon lags behind that of Karare.

Like Karare, the village of Kituruni has schools, shops, churches, and a government-run dispensary staffed by a local nurse. On the other hand, Kituruni is located several kilometers from the main road to Marsabit and is accessible only by treacherous roads, reducing the ability of Kituruni residents to access Marsabit hospital in case of severe health problems.

In addition to the permanent dispensaries, non-governmental organizations (NGOs), in particular, Food for the Hungry, International (FHI), are involved in health campaigns and famine relief distributions in the area. FHI is involved in many aspects of well-being in the area, including distributing medication and supporting vaccine campaigns, training community health workers, and running maternal/child health seminars. The Ariaal also rely on traditional medicine that is generally low-cost or free, although some plants may grow in distant areas. These medicines are often collected and prepared by the women themselves or requested from mobile pastoralists traveling through distant areas where the plants grow. No women mentioned consulting a *laibon*, or diviner/healer (Fratkin 1991), for infant medical problems. These three villages highlight the differential availability of health resources and provide a contrast for studying geographical barriers to treatment within the Ariaal population.

Methods

Data were collected in two separate field periods; the first, in October-November 2007 and the second in November 2008-January 2009. During the first data collection period, open-ended interviews and questionnaires were used to establish consensus models of maternal health knowledge while the second tested maternal health knowledge against infant growth and health outcomes in a large sample of breastfeeding mother-infant pairs. A summary of the data collection periods is found in Table 1. The protocols for this study were approved by the University of Michigan's Institutional Review Board and the Kenyatta National Hospital Ethics Review Committee.

Field Methods

Data Collection Period I. The first field data collection period took place in October-November 2007. This collection period, which established the basis for the culture consensus questions, was implemented in two phases. In the first phase, women (n = 11) were interviewed about infant illness and treatment in their community. Women in this sample were mothers from the village of Karare who were selected because they had varying degrees of health knowledge but are not necessarily representative of women in the community. Questions were posed in semi-structured interview form (Bernard, 2005) and were followed by probing questions when necessary.

The women's answers were compiled into a list that included the frequency of each response. All infant illnesses mentioned by the women were included in the second phase of data collection along with three symptoms mentioned most frequently by the women for each illness.

Western medical treatments mentioned at a frequency greater than one were included, as well as all traditional treatments mentioned for each illness. In addition, since some women stressed the importance of using different treatments depending on the kind and severity of illness, information about treatment options was included in the list of responses. These responses were converted into true-false questions (e.g. “Silalei is used to treat pneumonia in babies”; “It is better to treat malaria at home before going to the hospital”). In total, women’s interview responses generated 111 true-false questions relating to infant illness and treatment in Ariaal society.

The second phase of data collection combined this list of 111 questions with an additional 9 questions that related to basic characteristics of each woman, including number of children, self-reported poverty, latrine use, village, attendance at an NGO health seminar, use of medical facilities, and regularly boiling water for their infant. Each illness mentioned by the women – pneumonia, common cold, diarrhea, malaria, measles, ntingadu (joint pain, possibly brucellosis), eye infections, ear infections, worms, and an unspecified illness caused by a tick – also had questions relating to symptoms, treatment decisions, and Western and traditional treatments for illness. Thirty women took part in the second phase of data collection, answering true or false for all 111 questions. Women were recruited using non-probability quota sampling of interested women from two different villages. Fifteen women were from the village of Karare and fifteen were located in the village of Parkishon, located about 10 km away from Karare and the nearest dispensary.

Data Collection Period II. The second data collection period took place during November 2008- January 2009 and was part of a larger study involving mother-infant health, breastfeeding, and immunity. Questions from the traditional medicine subdomain (total = 46)

were administered alongside a detailed questionnaire and mother and infant anthropometric measurements. The traditional medicine questions were chosen because knowledge in this subdomain may be less dependent on access to Western medical facilities and may better represent potential knowledge across all villages. For this data collection period, a door-to-door survey was made of the villages of Karare, Kituruni, and Parkishon of lactating women; all breastfeeding women in these communities were invited to participate. While exact participation percentages are not available due to the mobility of some participants and change in breastfeeding status in others, 251 breastfeeding mother-infant pairs (infant ages range from 2 weeks to 25 months) from the villages of Karare, Kituruni, and Parkishon were ultimately recruited into this phase of data collection.

Mothers were administered a questionnaire that included questions relating to maternal and infant characteristics, family and household composition, socioeconomic status, recent infant illness, and hygiene behaviors. These questionnaires were translated orally into Samburu by two trained female research assistants. Infant age was calculated from the date of birth on their dispensary-issued health cards; mothers whose infants were too young to have been given their BCG vaccination reported infant age instead (5% of sample).

Anthropometric measurements were taken from both mothers and infants. Height (or recumbent length), weight, mid-upper arm circumference and triceps skinfold were measured using standard anthropometric techniques (Frisancho, 2008). Mothers and infants were weighed together and the weight of the mother subtracted to obtain infant weight. The weights of women who were wearing traditional jewelry were adjusted downward by 2.2 kg, the mean weight of 5 jewelry pieces (SD = 1 kg).

Statistical Methods

Data Collection Period I. In order to perform the cultural consensus analysis, quantitative data from the first data collection period, second phase, was organized into a large matrix, with participant on one axis and question on the other axis, and the true-false answer coded as either 0 or 1. The matrix was recompiled into four submatricies based on the relevant domain: illness knowledge, treatment decision making, knowledge of Western medicine, and knowledge of traditional medicine. In interviews, women indicated that these areas of knowledge were independent, and separating these questions into submatricies produced a better fit than when combined into one single matrix. Submatricies were analyzed using the cultural consensus process in ANTHROPAC v. 4.98 (Borgatti, 2006). This method uses factor analysis to determine the "correct" answer to each question, based on consensus, as well as the knowledge of each individual. It can obtain significant results with a small sample size (Romney et al., 1986).

Cultural consensus analyses begin by assuming individuals in the same group share one cultural model. To determine the best fit of this cultural model, it uses a least squares factor analysis with the minimum residual method. This procedure estimates and compares the cultural knowledge of each woman as well as the relative correctness of each answer. This process generates several factors, or eigenvalues, that can account for the variation found in the consensus matrix. The first eigenvalue represents the variance in the matrix due to sharing one cultural model, while the second eigenvalue represents variance due to other factors (Smith et al. 2004). In order for a submatrix to be considered a likely cultural domain, the ratio of the first eigenvalue to the second eigenvalue should be at least 1:3 with a ratio of 1:10 providing strong support for a "true" cultural domain (Borgatti, 1996; Romney, 1999). This indicates that the greatest amount of variance in the data is due to shared cultural knowledge rather than some

other effect, supporting the assumption of one cultural model. The ratio of eigenvalues for domains in this analysis range from 1:6.2 to 1:30.2, indicating a high degree of consistency of responses in each set of questions and confirming likely domains of Ariaal health knowledge.

Consensus analysis yields three useful results: 1) it determines the "correct" answer to each question by assessing the majority's answers, 2) it assesses the level of knowledge of each individual, and 3) it provides information about how well each question fits with other questions in the domain through comparison of eigenvalues. Since not all women are equally knowledgeable about infant health, individual knowledge levels of each health domain are the variables of interest for this study. Individual knowledge of a given domain is calculated based on the relationship of the woman's answers to the best fit consensus model, adjusted for guessing. It is determined on a scale from 0 to 1, with a higher number indicating higher levels of knowledge as assessed by cultural consensus.

Next, in order to determine what factors influence Ariaal women's level of health knowledge, women's knowledge scores in each of the four subdomains were associated with their community and individual characteristics. Number of children, village, latrine use, attendance at an NGO workshop on maternal/infant health, and self-described socioeconomic status ("poor" or "not poor") were statistically associated with women's knowledge in each subdomain using either a Pearson's correlation or independent two-sample t-test for populations with unequal variance. Significance was assessed at $\alpha = 0.05$.

Data Collection Period II. Traditional medicine questionnaire data were organized into a matrix and a cultural consensus analysis was performed as described above. The ratio of the first eigenvalue to the second eigenvalue for the traditional medicine subdomain is 1:9.2, indicating that the set of traditional medicine questions belongs to the same cultural subdomain. The

women's individual knowledge levels ranged from 0.70-0.95 (on a scale of 0 to 1; mean = 0.87 *SD* = 0.05), indicating that women on the whole were very knowledgeable about traditional medical treatments for infants.

After generating a traditional medicine knowledge score for each woman using cultural consensus, multivariate analyses were used to assess how maternal knowledge influences infant growth and health outcomes. Mothers' knowledge of the traditional medicine subdomain was the main independent variable in statistical analyses. Main dependent variables included reported infant illness within the past month, infant height-for-age z-score, and infant upper arm fat area. Mothers were asked to recall if their infants had experienced fever, respiratory, or diarrheal disease within the past month; these responses, indicated as no or yes, were combined into a "reported infant illness" variable coded 0 or 1. Infant recumbent length was transformed into height-for-age z-scores (HAZ) using the World Health Organization Child Growth Standards as the reference population (2006). HAZ is a measure of growth stunting and can indicate chronic nutritional deficiencies (de Onis & Blossner, 2003). Triceps skinfold indicates the amount of available body fat and can indicate short-term nutritional deficiencies. Triceps skinfold and mid-upper arm circumference were converted in to upper arm fat area (UAFA) using equations published by Frisancho (2008). UAFA was chosen as a dependent variable over triceps skinfold and mid-upper arm circumference because it adjusts triceps skinfold measurement to arm size, an important consideration in rapidly developing infants. In addition, mid-upper arm circumference and triceps skinfold were highly correlated with UAFA and yielded similar results in multivariate models. Statistical models were adjusted for mother's BMI, mother's age-adjusted parity (the residual of age regressed against parity; Tracer 1991), log-transformed total livestock units, attendance at an NGO-sponsored health seminar, mother having ever attended school,

household size, latrine use, self-reported poverty, village, infant sex and infant age. Total livestock units is a weighted measure of the livestock owned by a household, calculated by multiplying the number of cattle by 0.50, the number of sheep and goats by 0.10, and the number of camels by 1.10 and summing the results as described by the Food and Agriculture Organization (FAO) for sub-Saharan Africa (FAO, 2009). Ethnographic evidence suggests that livestock ownership remains an important source of wealth for settled Ariaal communities (Fratkin, 1998) and is the most important factor predicting self-reported poverty among this sample of women (Miller, unpublished data). Therefore, it has been included as a relative indicator of household wealth in the model in addition to self-reported poverty.

Multivariate models were performed in SAS 9.2. Infant illness was modeled using the LOGISTIC procedure and infant HAZ and UAFA were analyzed using the LINEAR procedure. Significance was assessed at $\alpha = 0.05$.

Results

Open-ended Interview

During the open-ended interview phase, the women tended to define infant illnesses in a similar fashion to Western definition of disease, particularly diarrhea, common cold and pneumonia, measles, malaria, worms, and eye and ear infections. There were two exceptions: ntingadu, whose symptoms include joint pain and weakness and which some women reported was brucellosis; and an unnamed illness that is caused by a tick, which is characterized by common cold symptoms and feelings of hot and cold throughout the body. Many women reported that it was not necessary to find the tick on the body in order to suspect this disease. It is unknown whether this corresponds to a tick-borne disorder in Western biomedical models.

Women indicated that there were generally two ways to treat an illness: treating with local herbs at home, and going to the medical dispensary staffed by a nurse who dispenses Western medicine. For severe disease, infants were often referred to Marsabit Hospital, which is located about 17 km from Karare. Women indicated that travelling there represented a serious hardship. Informants did not uniformly prefer Western or traditional medicines, indicating that for some illnesses, it was better to use Western medicines immediately, while for others it was acceptable to treat with traditional remedies before seeking out help at the dispensary.

Women in the open-ended interview phase of data collection were very adamant about which traditional medicines treated each disease and symptom, although they sometimes contradicted each other. They mentioned which medicines were not used to treat infants, citing medicines that were too strong for infants or that treated sexually transmitted infections. They also indicated how traditional medicines were prepared, ranging from boiling in milk or water to steaming herbs for inhalation. Samburu plant names were cross-checked with Heine et al. (1988), which relied heavily on Fratkin (1975, 1980), to confirm medicinal uses and species identification. By contrast, they were not as clear as to the scientific names of Western medicines, often preferring to describe them such as a “pink liquid”, a pill, or a shot. This demonstrates that mothers’ knowledge of Western medicine is not necessarily based in understanding of the biomedical paradigm but rather their experiences with Western medical facilities.

Domains of Health Knowledge

Means and frequencies of the characteristics of women who participated in the first data collection period, phase two is found in Table 2. Mothers’ knowledge of each cultural domain,

on average, tended to be high, with all women having a knowledge score of at least 0.65 (on a scale of 0 to 1). Women were the most knowledgeable about infant illness and least knowledgeable about Western medicine and treatment decision-making. Nearly every woman reported taking an infant to the dispensary at some point (96.7%). Pearson correlations between the four knowledge domains found two significant relationships. First, knowledge of traditional medicine was significantly associated with knowledge of Western medicine ($r = 0.49$, $p = 0.0059$). Second, knowledge of infant illness was significantly associated with knowledge of Western medicine ($r = 0.40$, $p = 0.030$). The other correlations were not statistically significant.

Characteristics Associated with Health Knowledge

The characteristics that are associated with women's knowledge in the four domains are reported in Table 3. Only two factors significantly predicted women's knowledge in any of the four domains: geographic location and latrine use. Women who lived in Parkishon, the village without a Western medical facility, had significantly less knowledge of infant illness and Western medicine than women who lived in Karare. Women who reported that they regularly used a latrine had significantly higher knowledge of traditional medicine, infant care decision-making, and Western medicine than women who reported that they did not. It should be noted that geography and latrine use are linked: two-thirds of the women who reported using a latrine live in Karare ($n = 10$), while only 20% of women who lived in Parkishon use latrines ($n = 3$). The interrelated effects of distant geographic location and lack of hygiene infrastructure appear to influence women's knowledge of health, particularly knowledge of Western medicine.

Maternal Traditional Medicine Knowledge and Treatment Seeking Behavior

Characteristics of women and infants who participated in the second data collection period can be found in Table 4. Women who participated in this period of the study had a similar level of knowledge of traditional medicine compared to women in the first data collection period. The second data collection phase also added the village of Kituruni to the analysis. One-way ANOVA indicates that there were significant differences in maternal knowledge across the three villages in this sample. A Tukey's range test indicates that the only significant pairwise comparison was between Karare and Kituruni, with women in Kituruni having a 0.01-point higher level of traditional medicine knowledge than women in Karare.

One hundred and forty-eight infants were reported to have been ill within the past month in the second data collection period. Overall, 67.6% of these infants were treated at a Western medical facility, while the remaining 32.4% of infants were only treated at home with traditional medicines. Women who took their child to the clinic may have treated their infant at home first but did not report it. Of children who were sick with a respiratory infection, 69% were treated at a Western medical facility, 37.5% of infants sick with diarrhea were treated at a Western medical facility and 91.7% of infants who were sick with a fever were treated at a Western medical facility. A Pearson's chi-square analysis of type of illness versus treatment location showed significant differences from expected proportions (χ^2 (2) = 16.4, p = 0.0003), indicating type of illness influences maternal treatment decision. Geographically, 69.9% of Karare infants, 46.7% of Parkishon infants, and 93.3% of Kituruni infants were treated for their illness at a Western medical facility versus being treated at home. These observations were significantly different from expected values (χ^2 (2) = 18.2, p = 0.0001), indicating geographic proximity to a Western medical facility influences maternal treatment decision-making. Self-reporting as "poor" did not appear to significantly influence choice of treatment location (χ^2(1) = 0.021, p = 0.88). Finally,

mothers who chose to treat their infants at the dispensary had marginally significantly higher levels of traditional medicine knowledge than women who chose to treat their infants at home ($t(146) = 1.84$, $p = 0.07$).

Mothers' Knowledge of Traditional Medicine and Infant Health Outcomes

Results of the multivariate analysis of mother's knowledge and infant health outcomes are found in Table 5. As mother's knowledge of traditional medicine increases, their infants were significantly less likely to have had an illness within the past month. Specifically, with each 0.01 increase in maternal knowledge of traditional medicine (on a scale of 0 to 1), each infant had a 9% lower likelihood of experiencing an illness within the past month. However, mother's knowledge of traditional medicine was not significantly associated with HAZ or UAFA.

Discussion

Ariaal women had high levels of consensus on concepts of illness, traditional and Western medicines, and care decision-making, indicating that these are likely Ariaal cultural domains. Knowledge of traditional medicine and knowledge of Western medicine are highly correlated within individuals. This may indicate that knowledge of Western medicine and traditional medicine could be considered one domain that simply represents medicine. On the other hand, it may show that women who are motivated to be knowledgeable about one type of medicine are motivated to be knowledgeable about another. Knowledge of Western medicine and knowledge of illness concepts are also correlated, corresponding with the open-ended interview answers that indicated that Ariaal women had a largely Western concept of illnesses. The exceptions to this were ntingadu (joint pain) and the disease caused by the tick; both of these

illnesses, while not directly tied to a known disease, appear to fall within the biomedical model of disease. Knowledge of care decision-making is not correlated with knowledge of any other cultural domain, indicating that knowledge of culturally appropriate health care decisions does not necessarily depend on knowledge of disease and treatment.

Public health infrastructure and proximity to a dispensary positively influenced health knowledge in Ariaal mothers. It may be that women who live in Karare have more opportunities for obtaining health knowledge than women who live in Parkishon. This is bolstered by the fact that Parkishon women knew less than Karare women about infant illness and Western medical treatments, two cultural realms that were likely influenced by Western medical thought. It may also be that women who have more general hygiene behaviors have greater knowledge of health overall, particularly in the realms of care decision-making and medicine. This geographic distance implicates differential access to resources as a factor that influences maternal knowledge of health.

Several factors predicted women's choice of where to treat sick infants. Geographic location played a major role: Kituruni and Karare women were more likely to take their infant to a health clinic than Parkishon women. The rate of treatment was even higher in Kituruni than in Karare. In Kituruni the government dispensary provides free health care to children under the age of five, while the Catholic dispensary in Karare charges fees for some services (local nurses, personal communication). In addition, certain types of illnesses were more likely to be treated at a dispensary: treating a fever at a dispensary appears to be a near-universal behavior and respiratory infections are treated there often, while infants were treated at the dispensary for treatment of diarrhea in only slightly over one-third of cases. The type of treatment given at the dispensary for each illness likely plays a role. Fevers are treated with anti-malarial and anti-fever

medications and respiratory infections are treated with antibiotic shots and medicines (local nurse, personal communication). Diarrhea is typically treated with oral rehydration salts, which women can make from ingredients in their home. Women who were knowledgeable about traditional medicine were somewhat more likely to take their infant to a dispensary when ill, lending credence to the idea that knowledge in one health domain indicates that women may be motivated to engage with the health systems within their communities, and have knowledge in more than one domain of health. Self-reported poverty, in contrast to other communities in Kenya (Mwabu et al., 1993), did not appear to keep women from seeking treatment at dispensaries. In this study, women only reported making the most time-consuming and costly treatment method; it is fairly likely that many treated their infant at home before resorting to the dispensary. Because of this, illness severity could be the top reason women take their infant to Western medical clinics; however these data were not collected in this study.

This study shows that indigenous and Western knowledges of health and treatment in the Ariaal community overlap considerably, and may in fact complement each other as is found in other populations (Giovannini et al., 2011). Ariaal women identify most illnesses with Western concepts of disease. Although women have much more specific knowledge about indigenous treatments than Western treatments, knowing the names of plants and how they are prepared, this does not dissuade women from using Western medical facilities. In addition, women who are the most knowledgeable about traditional medicine also know the most about Western medicine, demonstrating that health knowledge in this community may be based in individual motivation to learn about health rather than formal education or NGO seminars. Future research should follow up on the relationship between different domains of knowledge and child health outcomes and treatment. In addition, in line with a growing body of literature that suggests that culturally

appropriate health care can increase health service access for indigenous populations (Stephens et al., 2006), health care policy in northern Kenya can be improved by integrating traditional medicine knowledge with maternal education programs. This is especially important in light of the finding that infant health in the Ariaal community is greatly improved among knowledgeable mothers.

This study found that maternal health knowledge has a protective effect on infant illness, with even relatively small gains in knowledge. This finding confirms that maternal knowledge and infant well-being are linked even in populations with low rates of education. However, mothers' knowledge is not significantly associated with nutritional status. This result is not unexpected given the relatively low variation in maternal knowledge overall. In addition, the breastmilk fed to Ariaal infants may help buffer them against the nutritional disadvantages that may exist due to having less knowledgeable mothers. Finally, less-mobile and breastmilk-fed infants are less vulnerable to helminth infections that may slow growth (Tanner et al., 2011). These results differ somewhat from those found by McDade et al. (2007), who found that child HAZ, skinfold thickness, and C-reactive protein levels were positively associated with Bolivian mothers' ethnobotanical knowledge. McDade et al. (2007) were unable to distinguish between three causes for their results: 1.) more knowledgeable adults can better exploit the natural resources in their environment to feed their children better-quality diets, 2.) local plants may have beneficial pharmacological properties that influence children's well-being, or 3.) children who have more knowledgeable parents learn more about their environment and thus are better able to forage on their own. Since no Ariaal mother reported giving foraged food to infants as a weaning food, cause two is the most likely explanation for the relationship between health and maternal knowledge. However, a fourth cause should also be considered: mothers who are more

knowledgeable about traditional medicine may be knowledgeable in more than one domain of infant care, indirectly benefiting their infant's health. These results lend evidence to the idea that the boundary between Western and indigenous knowledge, rather than being distinct and fixed, is blurred and ever-changing based on community and individual needs (Agrawal, 1995).

Future investigations should consider how maternal knowledge of traditional medicine impacts infant illness in the Ariaal community. It may be that general health knowledge means that women are able to keep infants healthier. Or, women with high knowledge of ethnomedicine may be tapping into genuine medicinal properties of the plants that they use. For example, research has found some anti-malarial properties in *Harrisonia abyssinica* (Kirira et al., 2006), one of the plants identified in this study as having a traditional use. On the other hand, non-medicinal therapeutic properties of traditional medicine, such as the meaning effect (Moerman & Jonas, 2002) may create a complex interplay between the meaning of medicine to mothers and its proxy effect on infant health. Further research should attempt to tie the medical and cultural properties of plants with health outcomes in the Ariaal community (Reyes-García, 2010).

Much of rural Kenya faces geographical barriers to quality health care (e.g. Nyamongo, 2002). Results from this study confirm that geographic distance from a Western health dispensary plays a role in the treatment of infant illness in the Ariaal community. Building and staffing a dispensary in the community of Parkishon would likely improve the well-being of the infants in that community. In addition, adding educational programs for mothers and promoting public health behaviors such as latrine use would also likely improve health outcomes in the Ariaal community. Results from this study indicate that even relatively small gains in knowledge can influence infant health dramatically; because of this strong association policy workers should

incorporate ideas from both Western and traditional health care when developing health delivery plans for the Ariaal community.

Conclusion

Previous research has found that maternal education is strongly associated with improved infant health outcomes but has not been able to generalize this finding to populations with little formal education. This study demonstrated that cultural consensus methodology can be used to determine both Western and traditional health knowledge among Ariaal mothers of northern Kenya, who have little formal education but are highly invested in their infants' health. Ariaal mothers were found to integrate both Western and traditional approaches in their understanding of health and treatment; for example, women with greater knowledge of traditional medicine were marginally more likely to treat their infant's illness at a Western clinic. Even more striking is that greater maternal knowledge of traditional medicine was associated with a reduced likelihood of infant illness. These results confirm that maternal knowledge, regardless of education level, is associated with improved infant health outcomes and that indigenous knowledge systems should be incorporated into global health delivery plans when appropriate for the community.

References

Adano, W. R., & Witsenburg, K. M. (2008). *Pastoral sedentarisation, natural resource management, and livelihood diversification in Marsabit District, Northern Kenya.* Lewiston: Edwin Mellen Press.

Agrawal, A. (1995). Dismantling the divide between indigenous and scientific knowledge. *Development and Change*, 26(3), 413-439.

Barrera, A. (1990). The role of maternal schooling and its interaction with public health programs in child health production. *Journal of Development Economics,* 32(1), 69-91.

Basu, A. M., & Stephenson, R. (2005). Low levels of maternal education and the proximate determinants of childhood mortality: A little learning is not a dangerous thing. *Social Science & Medicine,* 60(9), 2011-2023.

Bernard, H. R. (2005). *Research methods in anthropology: Qualitative and quantitative approaches*. Walnut Creek: AltaMira Press.

Borgatti, S. P. (1996). *ANTHROPAC 4.0 Methods Guide*. Natick, MA: Analytic Technologies.

Borgatti, S. P. (2006). *ANTHROPAC*. Natick, MA: Analytic Technologies.

Caldwell, J., & McDonald, P. (1982). Influence of maternal education on infant and child mortality: Levels and causes. *Health Policy and Education,* 2(3-4), 251-267.

Caldwell, J. C. (1990). Cultural and social factors influencing mortality levels in developing countries. *The ANNALS of the American Academy of Political and Social Science,* 510(1), 44-59.

Cleland, J. G., & Van Ginneken, J. K. (1988). Maternal education and child survival in developing countries: The search for pathways of influence. *Social Science & Medicine,* 27(12), 1357-1368.

Cochrane, S. H., Leslie, J., & O'Hara, D. J. (1982). Parental education and child health: Intracountry evidence. *Health Policy and Education,* 2(3-4), 213-250.

de Onis, M., & Blossner, M. (2003). The World Health Organization global database on child growth and malnutrition: Methodology and applications. *International Journal of Epidemiology*, 32(4), 518-526.

Desai, S., & Alva, S. (1998). Maternal education and child health: Is there a strong causal relationship? *Demography*, 35(1), 71-81.

Dufour, D. L. (2006). Biocultural approaches in human biology. *American Journal of Human Biology,* 18(1), 1-9.

Elo, I. T. (1992). Utilization of maternal health-care services in Peru: The role of women's education. *Health Transition Review,* 2(1), 49-69.

Food and Agriculture Organization (2009). Compendium of agricultural-environmental indicators (1989-91 to 2000). Retrieved May 13, 2009, from http://www.fao.org/economic/ess/other-statistics/socio-economic-agricultural-and-environmental-indicators/compendium-of-agricultural-environmental-indicators-1989-91-to-2000/en/.

Fratkin, E. (1975). *Herbal medicine and concepts of disease in Samburu.* In I. o. A. Studies (Ed.). Nairobi: University of Nairobi.

Fratkin, E. (1980). *Concepts of health and disease among the Ariaal Rendille. Herbal medicine, ritual curing, and modern health care in a pastoral community in Northern Kenya.* London: University of London.

Fratkin, E. (1991). The loibon as sorcerer: A Samburu loibon among the Ariaal Rendille, 1973-87. *Africa* 61(3): 318-333.

Fratkin, E. M. (1998). *Ariaal pastoralists of Kenya: Surviving drought and development in Africa's arid lands.* Boston: Allyn and Bacon.

Fratkin, E. M., & Roth, E. A. (2004). *As pastoralists settle: Social, health, and economic consequences of the pastoral sedentarization in Marsabit District, Kenya.* New York: Kluwer Academic/Plenum Publishers.

Frisancho, A. R. (2008). *Anthropometric standards: An interactive nutritional reference of body size and body composition for children and adults.* Ann Arbor: University of Michigan Press.

Frost, M. B., Forste, R., & Haas, D. W. (2005). Maternal education and child nutritional status in Bolivia: Finding the links. *Social Science & Medicine,* 60(2), 395-407.

Fujita, M., Roth, E. A., Nathan, M. A., & Fratkin, E. (2004). Sedentism, seasonality, and economic status: A multivariate analysis of maternal dietary and health statuses between pastoral and agricultural Ariaal and Rendille communities in northern Kenya. *American Journal of Physical Anthropology,* 123(3), 277-291.

Giovannini, P., Reyes-García, V., Waldstein, A., & Heinrich, M. (2011). "Do pharmaceuticals displace local knowledge and use of medicinal plants? Estimates from a cross-sectional study in a rural indigenous community, Mexico." *Socal Science & Medicine,* 72(6): 928-936.

Heine, B., Heine, I., & Konig, C. (1988). *Plant concepts and plant use. An ethnobotanical survey of the semi-arid and arid lands of East Africa. Part V: Plants of the Samburu (Kenya).* Fort Lauderdale: Breitenbach.

Kirira, P. G., Rukunga, G. M., Wanyonyi, A. W., Muregi, F. M., Gathirwa, J. W., Muthaura, C. N., et al. (2006). Anti-plasmodial activity and toxicity of extracts of plants used in traditional malaria therapy in Meru and Kilifi Districts of Kenya. *Journal of Ethnopharmacology,* 106, 403-407.

McDade, T. W., Reyes-Garcia, V., Blackinton, P., Tanner, S., Huanca, T., & Leonard, W. R. (2007). Ethnobotanical knowledge is associated with indices of child health in the Bolivian Amazon. *Proceedings of the National Academy of Sciences of the United States of America,* 104(15), 6134-6139.

Moerman, D.E. & Jonas W.B. (2002). Deconstructing the placebo effect and finding the meaning response. *Annals of Internal Medicine,* 136(6): 471-476.

Muhuri, P. K. (1995). Health programs, maternal education, and differential child mortality in Matlab, Bangladesh. *Population and Development Review,* 21(4), 813-834.

Mwabu, G., Ainsworth, M., & Nyamete, A. (1993). Quality of medical care and choice of medical treatment in Kenya: An empirical analysis. *Journal of Human Resources,* 28(4), 838-862.

Nathan, M. A., Fratkin, E. M., & Roth, E. A. (1996). Sedentism and child health among Rendille pastoralists of northern Kenya. *Social Science & Medicine,* 43(4), 503-515.

Nyamongo, I. K. (2002). Health care switching behaviour of malaria patients in a Kenyan rural community. *Social Science & Medicine,* 54(3), 377-386.

Reidpath, D. D., & Allotey, P. (2003). Infant mortality rate as an indicator of population health. *Journal of Epidemiology and Community Health,* 57(5), 344-346.

Reyes-Garcia, V. (2010). The relevance of traditional knowledge systems for ethnopharmacological research: Theoretical and methodological contributions. *Journal of Ethnobiology and Ethnomedicine,* 6: 32.

Romney, A. K. (1999). Culture consensus as a statistical model. *Current Anthropology,* 40, S103-S115.

Romney, A. K., Weller, S. C., & Batchelder, W. H. (1986). Culture as consensus: A theory of culture and informant accuracy. *American Anthropologist,* 88(2), 313-338.

Ruel, M. T., Habicht, J.-P., Pinstrup-Andersen, P., & Gröhn, Y. (1992). The mediating effect of maternal nutrition knowledge on the association between maternal schooling and child nutritional status in Lesotho. *American Journal of Epidemiology,* 135(8), 904-914.

Smith, C. S., Morris, M., Hill, W., Francovich, C., McMullin, J., Chavez, L., Rhoads, C. (2004). Cultural consensus analysis as a tool for clinic improvements. *Journal of General Internal Medicine* 19(5): 514-518.

Stephens, C., Porter, J., Nettleton, C., & Willis, R. (2006). Disappearing, displaced, and undervalued: A call to action for indigenous health worldwide. *Lancet*, 367(9527): 2019-2028.

Tanner, S., Chuquimia-Choque, M. E., Huanca, T., McDade, T. W., Leonard, W. R., & Reyes-García, V. (2011). The effects of local medicinal knowledge and hygiene on helminth infections in an Amazonian society. *Social Science & Medicine,* 72(5), 701-709.

Tracer, D. P. (1991). Fertility-related changes in maternal body composition among the Au of Papua New Guinea. *American Journal of Physical Anthropology* 85(4): 393-405.

WHO Multicentre Growth Reference Study Group. (2006). *WHO child growth standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development.* Geneva: World Health Organization.

Table 1. Characteristics of fieldwork and collected data.

Fieldwork Period	Phase	*n*	Villages	Type of Data Collected
Period I	Phase I	11	Karare	Open-ended interview
(Oct-Nov 2007)	Phase II	30	Karare, Parkishon	True-false questionnaire
Period II		251	Karare, Parkishon, Kituruni	Traditional medicine true-false questionnaire, individual and household characteristics, anthropometric measurements of women and infants
(Nov 2008 – Jan 2009)				

Table 2. Health knowledge domains and individual characteristics of Ariaal women in Phase II of data collection Period I, total and by village.

Variable	Total *n* = 30 Mean (SD) or Freq (%)	Karare *n* = 15 Mean (SD) or Freq (%)	Parkishon *n* = 15 Mean (SD) or Freq (%)	Between-Village Differences *t* or χ^2(*p*)
Knowledge of illness*	0.91 (0.040)	0.90 (0.050)	0.93 (0.030)	2.0 (0.051)
Knowledge of traditional medicine*	0.85 (0.050)	0.85 (0.050)	0.86 (0.050)	0.76 (0.45)
Knowledge of Western medicine*	0.74 (0.15)	0.66 (0.16)	0.81 (0.10)	2.9 (0.0070)
Knowledge of care decision-making*	0.74 (0.060)	0.73 (0.060)	0.75 (0.060)	0.80 (0.43)
Number of children	4.1 (2.0)	4.1 (1.5)	4.0 (2.6)	0.086 (0.93)
Considered self poor (vs. not poor)	17 (56.7%)	8 (53.3%)	9 (60.0%)	0.14 (0.71)
Attended an NGO seminar	19 (63.3%)	10 (66.7%)	9 (60.0%)	0.14 (0.70)
Boiled water for infants	15 (50.0%)	8 (53.3%)	7 (46.7%)	0.13 (0.72)
Used a latrine	13 (43.3%)	10 (66.7%)	3 (20.0%)	6.7 (0.010)
Used dispensary if infant is sick	29 (96.7%)	15 (100.0%)	14 (93.3%)	1.0 (0.31)

* Range is from 0 to 1

Table 3. Relationship between maternal characteristics and knowledge of four health knowledge domains in Ariaal women in Period I, Phase II of data collection.

Maternal Characteristics	Cultural Domains			
	Illness Concepts	Traditional Medicine	Western Medicine	Treatment Decisions
Number of children	r = -0.27	r = 0.069	r = 0.0037	r = 0.32
Lived in Parkishon (vs. Karare)	t = -2.1*	t = -0.76	t = -2.9*	t = -0.80
Considered self poor	t = -0.87	t = -0.41	t = 0.070	t = 0.050
Attended an FHI seminar	t = -0.080	t = 0.85	t = 0.72	t = -0.34
Boiled water for infants	t = 0.33	t = 1.2	t = 0.56	t = -0.22
Used a latrine	t = 1.3	t = 2.2*	t = 2.1*	t = 2.1*

* indicates $p < 0.05$

Table 4. Maternal characteristics of Ariaal women in Period II of data collection by total population and village, including significant differences between villages (ANOVA and 3-way χ^2) and significant pairwise comparisons (Tukey's range test and 2-way χ^2).

Mean ± SD or %	Total (*n* = 251)	Karare (*n* =130)	Parkishon (*n* =68)	Kituruni (*n* = 53)	*p*-value
Maternal Characteristics					
Knowledge of traditional medicine	0.87 ± 0.05	0.87 ± 0.05	0.88 ± 0.05	0.88 ± 0.04	0.021[2]
Age (years)	27.5 ± 6.1	28.8 ± 6.4	26.3 ± 5.9	26.0 ± 5.2	0.0032[1,2]
Number of live births	3.5 ± 2.1	3.3 ± 2.0	3.6 ± 2.4	3.7 ± 2.2	0.48
BMI (kg/m^2)	18.5 ± 2.2	18.1 ± 2.2	18.8 ± 2.4	19.0 ± 1.9	0.019[2]
Attended NGO health seminar	43.4%	46.2%	35.3%	47.2%	0.28
% ever attended school	12.7%	14.6%	4.4%	18.9%	0.040[1,3]
Years of education	0.69 ± 2.1	0.82 ± 2.2	0.13 ± 0.71	1.1 ± 2.6	0.022[3]
Uses latrine	24.3%	22.3%	10.3%	47.2%	<0.0001[1,2,3]
Household size	3.3 ± 1.3	3.2 ± 1.3	3.4 ± 1.2	3.6 ± 1.4	0.15
% "poor"	18.3%	23.1%	14.7%	11.3%	0.12
Total livestock units	4.3 ± 4.5	3.5 ± 3.5	6.1 ± 6.3	4.2 ± 3.1	0.00030[1,3]
Infant Characteristics					
Infant age (months)	10.7 ± 6.0	10.6 ± 6.2	11.6 ± 6.7	9.8 ± 5.4	0.28
Infant height (cm)	69.8 ± 7.8	69.8 ± 7.7	70.0 ± 8.1	69.2 ± 7.5	0.86
Infant weight (kg)	7.6 ± 1.6	7.6 ± 1.6	7.6 ± 1.7	7.7 ± 1.5	0.92
Triceps skinfold (mm)	9.3 ± 2.5	8.7 ± 2.3	9.8 ± 2.6	10.2 ± 2.5	0.00030[1,2]
Mid-upper arm circumference (cm)	14.2 ± 1.3	14.2 ± 1.3	14.2 ± 1.4	14.3 ± 1.2	0.95
Height-for-age z-score	-0.83 ± 1.4	-0.72 ± 1.4	-1.1 ± 1.4	-0.71 ± 1.2	0.10
% Stunted	17.9%	16.9%	22.1%	15.1%	0.56
% Reported respiratory infection	43.0%	40.0%	52.9%	37.7%	0.15
% Reported diarrhea	10.8%	10.8%	11.8%	9.4%	0.92
% Reported fever	9.6%	10.0%	4.4%	15.1%	0.14[3]
% Reported illness	59.0%	56.2%	66.2%	56.6%	0.37

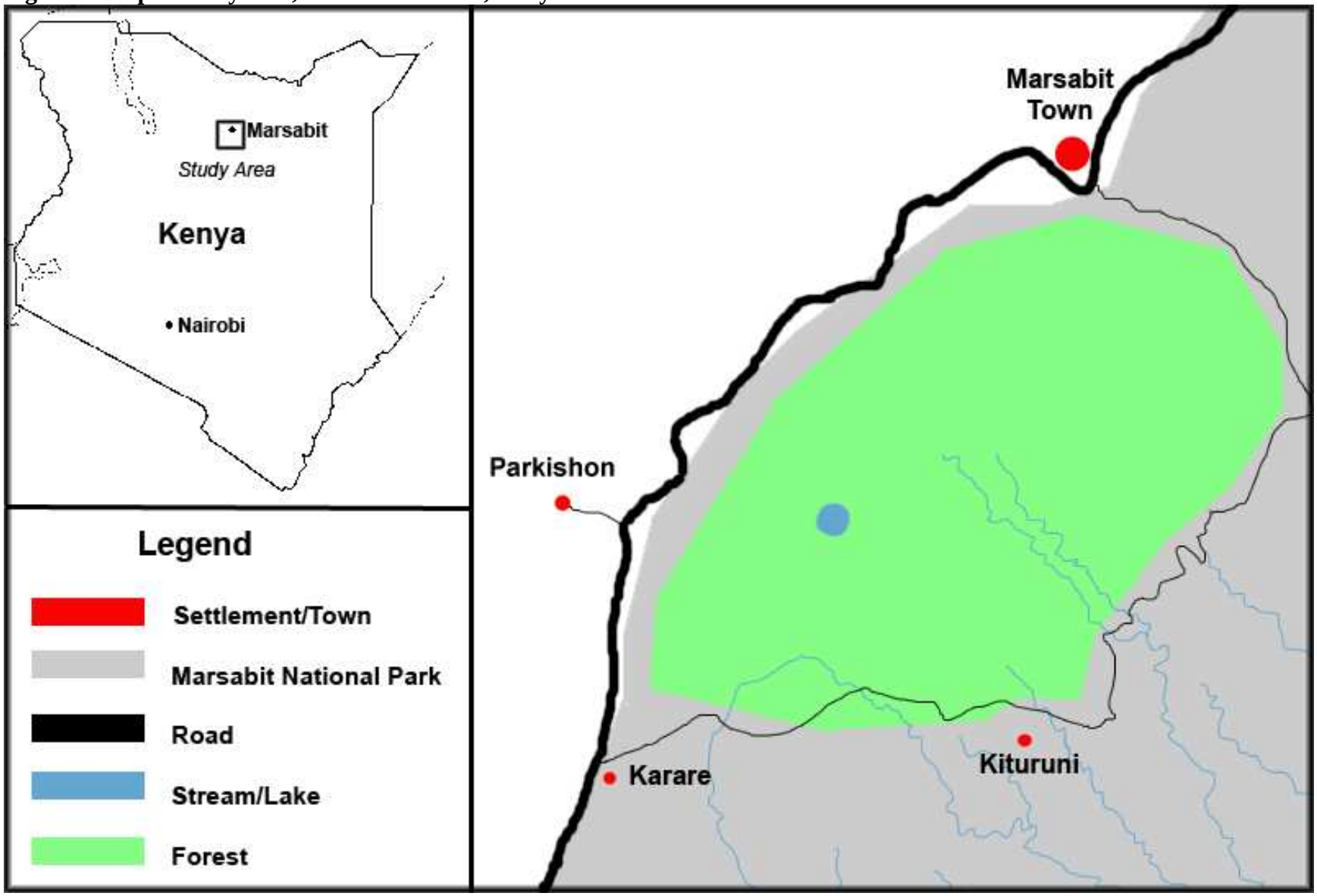
[1] Karare-Parkishon significant pair-wise comparison
[2] Karare-Kituruni significant pair-wise comparison
[3] Kituruni-Parkishon significant pair-wise comparison

Table 5. Odds ratios and estimates of infant health indicators regressed against maternal traditional medicine knowledge and covariates.

Independent Variables	Dependent Variables		
	Infant Illness OR(*p*)	UAFA β(*p*)	HAZ β(*p*)
Mothers' traditional medicine knowledge (unit = 0.01)	0.91(0.0054)**	0.020(0.42)	0.0025(0.89)
Mothers' BMI	1.1(0.10)	0.050(0.37)	0.13(0.0005)**
Mothers' age-adjusted parity	0.95(0.62)	-0.019(0.83)	-0.017(0.79)
Log total livestock units	1.4(0.16)	0.13(0.52)	-0.21(0.14)
Attended NGO health seminar	1.2(0.57)	-0.18(0.46)	-0.27(0.11)
Ever attended school	1.2(0.72)	0.12(0.72)	0.083(0.73)
Reports family as "poor"	3.7(0.0061)**	0.35(0.33)	-0.49(0.046)**
Uses latrine	0.57(0.10)	-0.27(0.33)	0.40(0.040)**
Household size	1.0(0.92)	-0.11(0.29)	0.016(0.83)
Family lives in Parkishon*	1.6(0.20)	0.60(0.044)**	-0.44(0.032)**
Family lives in Kituruni*	1.4(0.35)	0.99(0.0020)**	-0.44(0.049)**
Infant sex	0.97(0.90)	0.30(0.19)	-0.31(0.045)**
Infant age (months)	1.0(0.92)	0.090(<0.0001)**	-0.082(<0.0001)**
Infant illness	---	-0.053(0.83)	-0.034(0.84)
UAFA	1.0(0.89)	---	0.17(0.0001)**
HAZ	0.97(0.81)	0.36(<0.0001)**	---

* Reference Category is Karare
** $p < 0.05$

Figure 1. Map of study area, Marsabit District, Kenya.



Research Highlights:

- Cultural consensus can be used to determine domains of health knowledge in populations with little formal education
- Ariaal mothers integrate both Western and indigenous knowledge in their understanding of health and medicine
- Women with greater knowledge of traditional medicine are somewhat more likely to treat their infant's illness at a clinic
- Ariaal mothers' knowledge of traditional medicine is associated with lower likelihood of infant illness