

# Varied Reproductive Histories of Ethnically Tibetan Women

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## ABSTRACT

**Background:** The U.N. health and well-being goals for 2030 focus on maternal and child health outcomes, among others. Challenges to meeting those goals vary widely throughout Nepal owing to the range of sociocultural factors, infrastructural limitations, physical geography and altitudes. This article explores sociocultural and biological influences on fertility and child survival among ethnically Tibetan women in Nepal.

**Methods:** This is a cross sectional study of 430 women, age 46-86 years old, citizens of Nepal and native residents above 3500m in Mustang District, who provided interview and physiological data. Univariate Poisson regression analyses selected significant variables to include in multivariate Poisson regressions investigating the number of pregnancies, livebirths, child survival and death outcomes.

**Results:** Earlier age at first pregnancy, later age at last pregnancy, and miscarriages associated with more pregnancies. Miscarriages and stillbirths associated with fewer livebirths. Higher maternal BMI and FEV6 associated with fewer children dying before age 15. Marital characteristics (status, type, continuity), contraceptive use, relative wealth, and education influenced these covariates.

**Conclusions:** Low maternal pulmonary function and nutritional status predict poorer child survival in Upper Mustang. Addressing poor lung function and nutrition may improve reproductive outcomes among ethnically Tibetan women living at high altitude.

**Keywords:** Child survival; fertility; high-altitude; Nepal; women

## INTRODUCTION

The U.N. health and well-being goals for 2030 focus on maternal and child health outcomes, among others.<sup>1</sup> Challenges to meeting the goal of guaranteeing maternal and child health vary widely throughout Nepal, owing to a range of sociocultural factors, infrastructural limitations, physical geography, and altitudes. Life in the Himalaya adds the unique physical stressor of high-altitude hypoxia to sociocultural and biological factors linking maternal and child health outcomes. Hemoglobin concentration, percent of oxygen saturation of hemoglobin, and pulse predicted better reproductive outcomes for ethnically Tibetan women at high altitude in Nepal.<sup>2,3</sup> To further explore the extent to which maternal biological characteristics related to high-altitude adaptation and associate with reproductive success, we restudied women from Upper Mustang. The results identify points of intervention to meet the U.N. goal of health and wellness for all.

## METHODS

This is a cross sectional study of women who are citizens of Nepal who were born, raised and are currently residing at 3500 - 4200m in the northern settlements of Mustang District. They speak variants of Tibetan and Nepali and practice Tibetan sociocultural, economic, and religious traditions. They make a living through agriculture, animal husbandry, and trade.

Four hundred thirty women who were first sampled in a 2012 study<sup>2-5</sup> in Upper Mustang District participated in this follow-up study in 2019. The women averaged 60 years of age (SD 9.3), ranging from 46 to 86, in 2019. Data collection centered around field laboratories established sequentially in the three largest area villages: Lo Monthang (3800m), Tsarang (3500m), and Ghami (3500m). Recruitment occurred at those locations and surrounding villages. Village-wide meetings co-hosted by local elected officials, community leaders and the researchers reported the findings of the

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2012 study and described the 2019 study. We invited interested women to remain after these meetings to determine their eligibility to participate in the follow-up study. Other women visited the field laboratories to volunteer. Identification confirmation involved matching name, residence village, animal year of birth, name of husband, and the names and animal years of birth of the oldest and youngest child at the time of the earlier study in 2012. Eligible volunteers listened to information about the study provided in local variants of Tibetan language. Those who chose to participate provided written informed consent. Institutional review boards at Case Western Reserve University, Dartmouth College, the Nepal Health Research Council, and Washington University approved the study protocol.

Fieldwork took place during June and July 2019 in Mustang District, Nepal.

**Interview data:** U.S. researchers, trained nurses and local research assistants interviewed the study participants in the local dialect of Tibetan. 430 women updated or confirmed reproductive histories collected in 2012. Nineteen (4%) women corrected their ages by one to four years.

**Biological Measurements:** The women provided measures of weight, height, pulse, percent of oxygen saturation of hemoglobin, hemoglobin concentration (Masimo Pronto 7, Irvine, CA), pulmonary function (FEV6, forced expiratory volume at six seconds (equivalent to FVC, forced vital capacity), FEV1, forced expiratory volume at one second (Piko 6, Ferraris)), height without shoes and weight corrected for clothing. Body mass index (BMI, kg/m<sup>2</sup>) was calculated.

Means, standard deviations and frequencies (with percentages) were used to describe the variables of interest. The number of pregnancies, livebirths, and children surviving to and dying before fifteen years were the outcome variables in this study. We tested 29 potential sociocultural and biological predictors of the outcome variables and applied a Bonferroni correction to adjust for multiple comparisons. Univariate Poisson regression models for each outcome variable aided selection of the variables to include in multivariate Poisson regressions. An adjusted p value of  $\leq 0.05$  determined retention as covariates in the multivariable model. Each regression model included the percent of saturation of hemoglobin, pulse, and hemoglobin

concentration at the time of the study as covariates owing to their relevance for adaptation to high altitudes.<sup>2,3</sup>

Because some outcome variables constrain others, we used an offset variable in all regression models to adjust for the amount of opportunity an event had in our study population. The number of pregnancies adjusted for the opportunity of a live birth and the number of livebirths adjusted for survival and death child outcomes. Results from the multivariable regression models are shown as rate ratios with 95% confidence intervals (95% CI), where a rate ratio of  $>1$  indicates an increase and a rate ratio of  $<1$  indicated a decrease in the outcome of interest.

This report displays the exponentiated values of the regression coefficients.

## RESULTS

Women averaged 5.3 pregnancies and 3.6 children surviving to age 15. 14% of women had one or more miscarriages, and 10.7% had one or more stillbirths (Table 1).

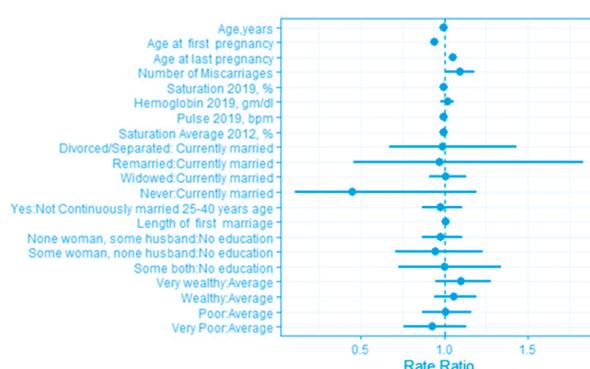
**Table 1.** Reproductive history and biological character of ethnically Tibetan women residing at 3500m or higher in Nepal (N=430).

Variable	Mean (S.D.)
Mean age in years	60 (9.3)
Mean age at first pregnancy in years	23.82(4.3)
Mean age at last pregnancy in years	36.16(6.0)
Average number of pregnancies	5.34(2.9)
Average number of live births	5.23 (2.7)
Number of infants surviving > 1 year	4.26(2.2)
Number of children surviving >5 years	4(2.0)
Number of juveniles surviving >15 years	4(1.9)
Length of the first marriage, years	26(11.12)
Hemoglobin concentration, gm/dl	13.9(1.33)
Oxygen Saturation of hemoglobin, %	86.2(4.09)
Pulse, bpm	72.9(9.26)
BMI, kg/m <sup>2</sup>	21.2(3.05)
FEV6, L	2.7(0.67)

**Table 2a. Reproductive history of ethnically Tibetan women residing at 3500m or higher in Nepal (N=430).**

Variable	Count/(%)
Number of children dying before the age of 15	
0 deaths	152(38)
1 death	102(25)
2+ deaths	149(37)
Number of Stillbirths	
0 Stillbirths	376(90)
1 Stillbirth	41(10)
2+ Stillbirths	3(0.7)
Miscarriages	
0 Miscarriages	361(86)
1 Miscarriage	43(10)
2+ Miscarriages	16(4)
Current contraceptive use	
Never	251(59.1)
In the past/not currently	83(19.5)
In the past and currently	91(21.4)

Ages at first and last pregnancies (averaging 24 and 36 years, respectively) predicted the number of pregnancies. A one-year younger age at first pregnancy was associated with 6% percent more predicted pregnancies (*Rate ratio*: 0.94, 95% *CI*: 0.93-0.95, *p*<0.001). A one-year older age at last pregnancy predicted 5% percent more predicted pregnancies (*Rate ratio*: 1.05, 95% *CI*: 1.04-1.06, *p*<0.001). A miscarriage predicted 9.5% percent more pregnancies (*Rate ratio*: 1.095, 95% *CI*: 1.01-1.18, *p*=0.02). Rate Ratios above 1.0 indicate more and those below 1.0 indicate fewer pregnancies. Intervals including 1.0 are not significant. (Figure-1)

**Figure 1. Factors influencing the number of pregnancies, expressed as Rate Ratios (N=430).**

Controlling for the number of pregnancies, the number of miscarriages and stillbirths predicted the number of livebirths. A miscarriage predicted 12% percent fewer live births (*Rate ratio* 0.88, 95% *CI*: 0.81-0.95, *p*=0.002). A stillbirth predicted 17% percent fewer live births (*Rate ratio* 0.83, 95% *CI*: 0.72-0.94, *p*=0.005).

**Table 2b. Sociocultural characteristics of ethnically Tibetan women residing at 3500m or higher in Nepal (N=430).**

Marital status	
Currently married	250(58.1)
Divorced/Separated	17(4.0)
Never married	17(4.0)
Remarried	4(0.9)
Widowed	142(33.0)
Marital type	
No cousin / no polyandry	342(79.5)
Never married	26(6.0)
Yes cousin / no polyandry	25(5.8)
No cousin / yes polyandry	33(7.7)
Yes cousin / yes polyandry	4(0.9)
Married continuously through 25-40 years	
No	191(44.4)
Yes	239(55.6)
Relative Wealth Rank	
Very wealthy	51(12.7)
Average	100(24.8)
Wealthy	135(33.5)
Poor	77(19.1)
Very Poor	40(9.9)
School attendance	
No education for husband or wife	280(65.1)
No education for woman, some for the husband	122(28.4)
Some education for woman, none for the husband	13(3.0)
Some education for both	15(3.5)

Controlling for the number of livebirths, none of the measured maternal sociocultural or biological characteristics contributed to variation in child survival (Tables 2a & 2b).

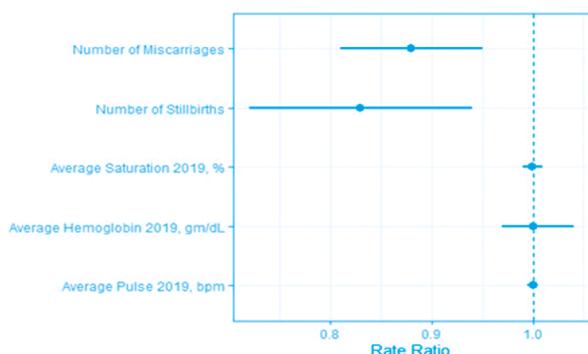


Figure 2. Factors influencing the number of live births, expressed as rate ratios (N=419).

The reproductive histories of 419 women who had experienced a pregnancy. Intervals including 1.0 are not significant; those below 1.0 indicate fewer livebirths.

In contrast, maternal biological characteristics did contribute to variation in child deaths. Within our study population, 38% of women reported none, 25% reported one and 37% reported two or more children dying before the age of 15. Past and current contraceptive use trended toward predicting fewer child deaths before age 15 compared with women who had never used contraception (Rate ratio: 0.74, 95% CI: 0.552-1.03,  $p=0.079$ ). A one-unit increase in BMI predicted 5% percent fewer child deaths before age 15 (Rate ratio: 0.95, 95% CI: 0.92-0.98,  $p=0.004$ ). A one-liter larger FEV6 predicted 18% percent fewer child deaths before age 15 (Rate ratio: 0.82, 95% CI: 0.699-0.97,  $p=0.018$ ).

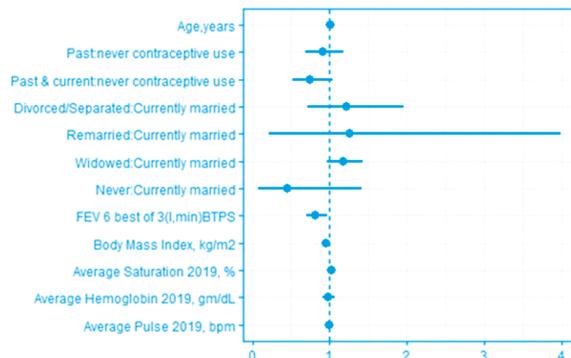


Figure 3. Factors influencing the number of children dying before 15 years expressed as Rate Ratios (n=415).

415 women who had experienced a livebirth. Intervals including 1.0 indicate non-significance. Rate Ratios below 1.0 indicate fewer child deaths.

To better understand influences on the significant predictors of ages at first and last pregnancy, and

number of miscarriages, we examined marital status, marital type, marriage continuity from the ages of 25-40, contraceptive use, household relative wealth, and education. Being married continuously from ages 25-40 years of age and a household with high relative wealth both associated with an earlier age at first pregnancy. Women who had never married or used contraception had a later age at first pregnancy. Women who have never married or had a disrupted marriage had an earlier last pregnancy. Those who had never used contraception or who had no education (both wife and husband) had a later age at last pregnancy.

Miscarriage predicted the number of pregnancies and the number of live births in a women's reproductive career. Stillbirths predicted the number of livebirths. Just one of the tested sociocultural variables - relative wealth - associated with prenatal loss. Many more women from households ranked as poor and very poor reported a stillbirth: 16 and 20% among the poor and very poor reported one or more stillbirths compared to 2% of the very wealthy.

Concerning the predictors of number of children dying, older women had lower BMI ( $r_{FEV6-Age} = -0.162$ ,  $p=0.001$ ). Women from relatively wealthy households had an average BMI of ~23 compare with other women who had an average of ~21 kg/m<sup>2</sup>, a difference that predicts ten percent fewer child deaths among the better off women.

Older or shorter women had smaller lung volumes ( $r_{FEV6-age} = -0.429$ ;  $r_{FEV6-height} = 0.383$  ( $p<0.001$ )). Just four percent of women smoked. Type of cooking fuel associated with FEV6. Women who cooked only with biofuels (wood or dung) had lower FEV6 than those using a combination of gas and biofuel: 2.41 L compared with 2.72 L. That FEV6 difference is roughly equivalent to a ten-year age difference.

## DISCUSSION

This follow-up study revisited about 40% of the participants from an earlier study and confirmed many of the previous results, as expected, despite the smaller sample and lower statistical power. This study added analyses of the number of children dying before age 15 and maternal biological characteristics to detect factors significantly associated with the number of pregnancies, livebirths, and children dying before age fifteen.

Age at first and last pregnancy and number of miscarriages associated with the number of pregnancies. Finding that women from poor households had more

stillbirths (associated with fewer livebirths) and lower BMI (associated with more children dying) suggests the benefits of economic and nutritional interventions as a means of improving maternal and child health. These are broadly consistent with findings from other studies of South Asian and Nepalese women.<sup>6,7</sup> Poor women had lower BMI and worse reproductive outcomes, also consistent with other studies.<sup>8</sup>

The association of higher FEV6 with fewer children dying aligns with another study that looked at indoor air pollution in Chaurikharka in the Khumbu Valley. The researchers found that longer duration and intensity of air pollution associated with early pulmonary and cardiovascular damage.<sup>9</sup> The high altitude location of our study raises the possibility that variation in FEV6 reflects variation in adaptation to hypoxia. FEV6 (equivalent to FVC) is usually higher at altitude compared to unexposed individuals.<sup>10</sup> We suggest that women with larger lungs may have had children with larger lungs, owing to shared inherited factors and growth at high altitude.

A limitation of this study is not knowing the extent to which these maternal characteristics reflect those at the time of childbearing. Hemoglobin concentration, percent of oxygen saturation of hemoglobin, and pulse showed stability from 2012 to 2019.<sup>11</sup> It is possible that some women may have reported a pregnancy loss as a miscarriage or vice versa; however, if this occurred, it would not change the conclusion regarding the importance of prenatal loss. It is also worth noting that women in our study gave birth from 1943 to 2012, a time of substantial changes in health care policy and access in Nepal.

A strength of this study comes from the researchers' long experience working with Tibetan populations, including those in Mustang, and extensive knowledge of the culture and location.<sup>12-14</sup> The researchers and these women have worked together before, increasing the likelihood that they felt comfortable with the interviews and measurements. Conducting the interviews in local dialects of Tibetan by trained research assistants from Upper Mustang improved trust, communication and information collection. The women surveyed have completed their reproductive careers, thus ensuring that our analyses cover their complete reproductive history, including child mortality.

## CONCLUSIONS

Reproductive success is influenced by prolonged

exposure to pollutants during pregnancy, poverty and BMI. This study added new information on the role of maternal biology that could reflect indoor air pollution, nutritional status, or high altitude adaptation. Reducing prenatal loss, along with improving women's nutritional status and pulmonary health would likely improve both maternal and child health in Upper Mustang and move toward achieving the U.N. Sustainable Development Goals in this region of Nepal.

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**Competing interests:** None declared

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