

ALTITUDE AND DEMOGRAPHY AMONG THE SHERPAS

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Summary. The Sherpas of Upper Khumbu (above 10,000 feet), Nepal, and their migrant counterparts at lower altitudes (3000-7000 feet) in Darjeeling District, West Bengal, show no statistically significant difference in age-sex structure or mortality, while there are suggestions of some fertility reduction at the higher altitudes.

Introduction

The precise effects of environmental stresses associated with high altitude on specific human traits are little known, and somewhat contradictory results have been obtained from studies conducted in Latin America and East Africa (Baker & Dutt, 1972; Mazess, 1975; Cruz-Coke, 1977). In view of this, comparison of the demography of two altitudinal subgroups of the Sherpas was undertaken.

The Sherpas of Solu-Khumbu, north-east Nepal, are an offshoot of the larger Tibetan population. They moved from eastern Tibet to their present habitat around 1533 (Haimendorf, 1964; Oppitz, 1974). Their Tibetan ethnic origin is evident in their Tibetan dialect and their religion, the Tibetan sect of Buddhism. The Upper Khumbu region in north-east Nepal lies between 27°45' and 27°55' N, and 86°40' and 86°50' E, immediately adjacent to the Tibetan border. In the triangle enclosed by Dudh Khosi and Bhote Khosi are located the villages of Namche Bazar, Khumjung, Khunde; in the upper Dudh Khosi valley Phortse, Devuche, Thyangboche; and in the Bhote Khosi valley Thami, Thamo, Thamote, collectively known as Thamicheck. In Upper Khumbu, the villages are situated between altitudes of 10,000 and 14,000 feet. The climate of this region is wet and humid during the summer and monsoon (June-September) and dry and very cold during the winter (October-March).

In India, the Sherpas are mainly concentrated in the Sadar and Kalimpong subdivisions of Darjeeling District, West Bengal. Kalimpong lies between 26°51' and 27°12' north, and 88°28' and 88°53' east. Here the Sherpa villages are mainly situated at lower altitudes between 3000 and 9000 feet. The present study was undertaken in the following villages or hamlets: Upper Echhay Sherpagaon, Algarah, Lava, Pashiting, Pasangbung and Munsong Cinchona Plantation, at altitudes 3000-7000 feet. The climate in this region is cool and pleasant in summer, but bitterly cold in winter. The rainy season extends from May to September, and humidity is high during April and May. According to oral tradition, the Sherpas

migrated into Kalimpong about two centuries ago, most of them directly from Solu-Khumbu and some via Sikkim.

The purpose of this report is to compare the demographic characteristics of the Sherpas of Upper Khumbu and their migrant counterpart in Kalimpong.

Material and methods

The demographic data were collected from 250 households in Kalimpong and 110 households in Upper Khumbu. The basic design, following the recommendations of the Human Adaptability Panel of the International Biological Programme (Baker & Dutt, 1972), essentially involves a comparison between two subunits of a population native to high altitude, one which continues to live at high altitude, in this case the Sherpas of Upper Khumbu (10–14,000 feet) and another which has migrated to lower altitudes, here those at 3–7000 feet in the Kalimpong subdivision of the Darjeeling District. The similarities between the two samples will help in identifying the traits which are genetic and due to common ancestry, and the differences in identifying those which are due to adaptation. The demographic information was collected using household and fertility questionnaires. The first was completed using information on age, sex, marital status and place of birth from the head of each household or, where absent, from some elderly member of the household. The fertility schedule was completed using information from married females on their reproductive performance (live births, dead children, reproductive wastage, preferential marriage, polyandry). Great difficulties were experienced in the assessment of age, as there is no tradition of keeping birth registration or any written record among the Sherpas. Age was therefore estimated by reference to some important local events, and cross-checked from a number of elderly individuals. The reproductive wastage data are considered unreliable and have not been utilized.

Results

About 40, 50 and 11% of the population in Kalimpong and about 43, 46 and 11% in Upper Khumbu are in the 0–14 years, 15–49, and 50+ age groups respectively (Table 1) suggesting a potentially growing population. There is no significant difference between the two samples in age/sex structure (χ^2 5.21, df 7, $P > 0.05$). The overall sex ratio is 52.97 ± 1.31 , and 50.46 ± 2.15 in the Kalimpong and Upper Khumbu subgroups respectively. There is a constriction at the base of the population pyramid in both the areas (Fig. 1), suggesting a recent drop in fertility or recent high infant mortality. In the absence of any known recent epidemic or any other cause of death involving largely the infants, a recent drop in fertility seems more likely. Table 1 also shows the total populations of the households surveyed in the two areas by age, sex and marital status. It appears that 93% of unmarried males in Kalimpong and 89.6% in Upper Khumbu are aged 24 years and below, and so are 96.0 and 93.9% respectively of unmarried girls; this shows that most of the middle-aged and elderly individuals are married or have been married at least once, a situation conducive to high fertility. However, the child:woman ratio is

50.4 in Kalimpong and 60.3 in Upper Khumbu, indicating only moderate fertility by comparison with the ratio in a few high fertility populations, e.g. the Hutterites and Dinka (Eaton & Mayer, 1953; Roberts, 1956).

Monogamy is the main form of marriage among the Sherpas of both areas (Table 2): about 92% of marriages are monogamous in Kalimpong, and 95% in Upper Khumbu, with only rare instances of polygynous and polyandrous marriages in both. Village endogamy is lower in Kalimpong than in Upper

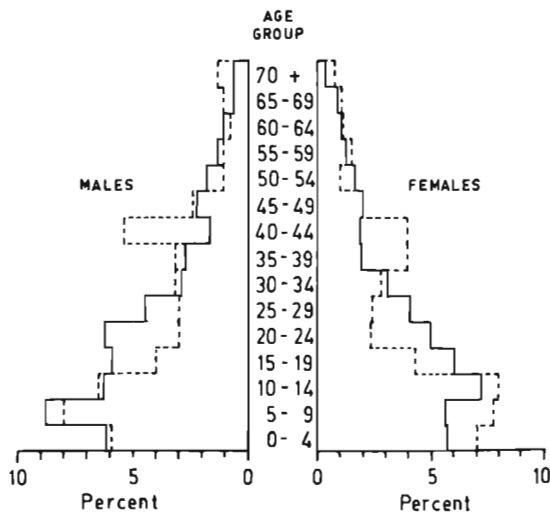


Fig. 1. Population pyramid for Kalimpong (—) and Upper Khumbu (---) areas.

Khumbu: 40.8% of the marriages are contracted within villages in Kalimpong and 76.5% in the high altitude group, implying in the latter either a cultural preference for marrying within the village, or a restriction of movement imposed by the very difficult nature of the terrain. In Kalimpong only 4.05%, and in Upper Khumbu 2.38%, of married women had never been pregnant (Table 3). These frequencies of childless women are indeed low. That they do not necessarily indicate high fertility is shown by the mean completed family size in women past reproductive age (Table 4); this is high (7.44) in Kalimpong, but only moderate (4.53) in Upper Khumbu, and the difference between them is significant ($t = 4.10$, $df 86$, $P < 0.05$). With respect to the mean number of live births per mother in the age groups 25-29, 30-34, 35-39, and 40-44 years, the differences between the Kalimpong and Upper Khumbu subgroups are not significant (Table 4). The net reproductive index is

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40-44	No.	2	19	21	3	5	24	26		27	19	2	2	29	21
	%						1.7	1.8						5.4	3.9
45-49	No.		30	25	2	3	32	28		1	13	9	1	13	11
	%						2.2	1.9						2.4	2.0
15-49	No.	192	131	177	193	9	15	717		53	39	75	73	2	246
	%							49.6							43.6
50-54	No.	1	20	19	6	4	26	24		6	5			6	5
	%						1.8	1.7						1.1	0.9
55-59	No.		20	13		5	20	18		1	6	5	2	6	8
	%						1.4	1.2						1.1	1.5
60-64	No.	1	11	5	4	9	16	15		2	5	2	1	4	6
	%						1.1	1.0						0.7	1.1
65-69	No.		7	7	3	5	10	12		1	1	4	1	6	5
	%						0.7	0.8						1.1	0.9
70+	No.		6	2	4	3	10	5		7	3	3	1	10	4
	%						0.7	0.3						1.8	0.7
50+	No.	1	2	64	46	17	26	156		1	2	25	22	6	4
	%							10.8							11.1
Totals	No.	499	400	241	239	26	41			164	164	100	95	8	8
	%	34.5	27.7	16.7	16.5	1.8	2.8			30.4	30.4	18.6	17.6	1.5	1.5
	No.	899	480	67			1446			328	195	16			539
	%	62.1	33.2	4.6			100.0			60.8	36.2	3.0			100.0

* Widowed, divorced, separated.

Table 2. Multiple marriages

Area	Individual married								More than once married	
	Once		Twice		3 Times		Total		Ratio: All married	
	M	F	M	F	M	F	M	F	M	F
Kalimpong	210	247	18	14	3	0	231	261	9.09	5.26
Total	457 (92.9)		32 (6.5)		3 (0.6)		492 (100.0)		7.1	
Upper Khumbu	83	96	7	2			90	98	7.8	2.0
Total	179 (95.2)		9 (4.8)				188 (100.0)		4.8	

Figures in parentheses are percentages.

Table 3. Numbers of married women never pregnant and pregnant at least once by age group

	Age group (years)								Total	
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54		55+
Kalimpong										
Never pregnant	1	1	4	0	1	1	0	0	2	10
Pregnant at least once	1	25	39	32	25	23	27	24	41	237
Total	2	26	43	32	26	24	27	24	43	247
% never pregnant	50.00	3.85	9.30	0	3.85	4.17	0	0	4.65	4.05
Upper Khumbu										
Never pregnant	0	0	0	0	0	1	0	0	1	2
Pregnant at least once	0	4	8	13	18	17	9	2	11	82
Total	0	4	8	13	18	18	9	2	12	84
% never pregnant	0	0	0	0	0	5.55	0	0	8.33	2.38

3.36 and 2.00 in Kalimpong and Upper Khumbu respectively. The average number of live births to ever married fertile women by age groups (Table 5) is 5.00 in Kalimpong and 4.06 in Upper Khumbu. In each age group from 30-34 onwards, the Kalimpong women show a slightly higher average number of live births, both to all women and per fertile woman. Table 6 shows the average numbers of live births and surviving children per married woman of 4.74 and 3.88 respectively in Kalimpong, and 3.91 and 2.49 respectively in Upper Khumbu; the difference between the two subgroups with respect to live births is significant at the 5% level.

Table 4. Live births by age group of married women living in wedlock

No. of live births	No. of women aged:													
	25-29			30-34			35-39			40-44			45+	
	Kalimpong	Upper Khumbu	Upper Khumbu	Kalimpong	Upper Khumbu	Upper Khumbu	Kalimpong	Upper Khumbu	Upper Khumbu	Kalimpong	Upper Khumbu	Kalimpong	Upper Khumbu	
0	3	0	0	0	0	0	1	0	0	1	1	2	1	
1	11	1	1	1	1	1	1	1	0	2	1	2	1	
2	10	3	2	2	1	3	3	3	3	1	1	2	4	
3	10	1	6	3	3	3	3	5	1	1	1	3	1	
4	5	1	10	2	2	3	4	4	4	3	4	2	1	
5	1	2	5	1	1	6	6	4	3	3	4	6	5	
6	2	0	4	3	3	3	3	2	2	2	1	6	0	
7	0	0	1	1	1	2	1	1	3	1	1	6	3	
8	0	0	1	0	0	2	0	0	3	3	3	9	3	
9	0	0	0	0	0	0	0	0	1	0	0	10	0	
10	0	0	0	0	0	1	0	0	0	0	0	11	0	
11	0	0	0	0	0	0	0	0	1	0	0	3	0	
12	0	0	0	0	0	0	0	0	0	0	0	3	0	
13	0	0	0	0	0	0	0	0	0	0	0	1	0	
14	0	0	0	0	0	0	0	0	0	0	0	1	0	
Total	42	8	30	12	12	25	18	18	19	17	17	69	19	
Mean no. of births/woman	2.26	3.00	3.77	3.83	3.83	4.64	3.89	5.42	4.65	4.65	7.44*	4.53*		
σ	1.34	1.41	1.50	1.77	1.77	2.31	1.41	2.91	2.27	2.27	3.09	2.48		
	1:1.48, df/48, NS	1:0.35, df/40, NS	1:0.45, df/41, NS	1:0.87, df/34, NS	1:0.87, df/34, NS	1:0.87, df/34, NS	1:0.87, df/34, NS	1:0.87, df/34, NS	1:0.87, df/34, NS	1:0.87, df/34, NS	1:4.10, df/86, P < 0.05	1:4.10, df/86, P < 0.05		

* Completed family size.

Table 5. Numbers of ever-married women and live births, by age group

	Age group (years)										Total	
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55+			
Kalimpong												
Never pregnant	1	1	4	0	1	1	1	0	0	2	10	
Pregnant at least once	1	25	39	32	25	23	27	24	41	237		
Total number of women	2	26	43	32	26	24	27	24	43	247		
Total live births	1	50	98	135	124	127	213	175	263	1186		
Average no. of live births/ fertile woman	1.00	2.00	2.51	4.22	4.96	5.52	7.89	7.29	6.11	5.00		
Upper Khumbu												
Never pregnant	0	0	0	0	0	1	0	0	1	2		
Pregnant at least once	0	4	8	13	18	17	9	2	11	82		
Total no. of women	0	4	8	13	18	18	9	2	12	84		
Total live births	0	6	24	51	74	80	51	8	39	333		
Average no. of live births/ fertile woman	0	1.50	3.00	3.92	4.11	4.70	5.67	4.00	3.54	4.06		

Table 6. Numbers of married women by surviving and total sibship size

	No. of surviving children														Total	No. of surviving children/woman	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13			14
Kalimpong																	
No. of women	8	28	44	33	26	23	14	14	7	10	3	2	1	0	0	213	3.88
%	3.75	13.14	20.66	15.49	12.21	10.80	6.57	6.57	3.29	4.69	1.41	0.94	0.47			100.00	
Upper Khumbu																	
No. of women	2	8	19	11	13	11	10	4	0	0	0	0	0	0	0	78	2.49
%	2.56	10.26	24.36	14.10	16.67	14.10	16.67	14.10	12.82	5.13						100.00	
	No. of live births														Total	No. of live births/woman	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
Kalimpong																	
No. of women	8	25	30	21	21	17	14	15	11	12	4	3	1	1	213	4.74*	
%	3.75	11.74	14.08	14.08	9.80	9.86	7.98	6.57	7.04	5.16	3.63	1.88	1.41	0.47	100.00		
Upper Khumbu																	
No. of women	2	6	14	9	13	16	6	6	6	6	6	6	6	6	78	3.91*	
%	2.56	7.69	5.13	11.54	16.67	20.51	7.69	7.69	7.69	7.69	7.69	7.69	7.69	7.69	100.00		

* $t_{2,18}$, df 289, $P < 0.05$.

Table 7. Live births during each 5-year period to married women living in wedlock

	Age group (years)							Total
	15-19	20-24	25-29	30-34	35-39	40-44	45+	
Kalimpong								
No. of women	213	212	180	143	114	89	71	213
No. of live births	88	239	263	203	130	60	27	1010
No of live births/woman	0.413	1.127	1.461	1.420	1.140	0.674	0.380	6.616*
Upper Khumbu								
No. of women	78	78	74	66	54	36	19	78
No. of live births	18	76	88	65	50	15	7	319
No. of live births/woman	0.231	0.974	1.189	0.985	0.926	0.417	0.368	5.090*

* Total fertility rate.

Table 7 shows that the total fertility rate is 6.61 in Kalimpong and 5.09 in Upper Khumbu. It thus appears that there are suggestions of higher fertility in the lower altitude sample, and that this attains statistical significance in the case of the average number of live births and in the completed fertility in women past reproductive age.

Table 8 shows that out of 1186 births to the Kalimpong mothers and of 333 births to Upper Khumbu mothers, respectively 78 and 24 infants (6.58% and 7.21%) died before the age of one year. The binomial test for equality of proportions shows that this difference is not significant (0.006 ± 0.016). Mortality before the age of reproduction (i.e. before 15 years) is 17.1% in Kalimpong and 13.2% in Upper Khumbu, and again the difference is not significant (0.039 ± 0.023). Similarly, there is no significant difference between the two subgroups in infant and adolescent mortality in the offspring of older women (45+ years), the difference in infant mortality being 0.015 ± 0.027 , and in adolescent mortality 0.034 ± 0.045 .

Table 8. Infant mortality and mortality before reproductive age

Area	Total no. of births	All mothers				Mothers aged 45+				
		Mortality				Mortality				
		Before 1 year		Before 15 years		Before 1 year		Before 15 years		
No.	%	No.	%	No.	%	No.	%			
Kalimpong	1186	78	6.58	203	17.12	513	28	5.46	95	18.52
Upper Khumbu	333	24	7.21	44	13.21	86	6	6.98	13	15.12

Discussion

It appears from animal as well as human studies (Hock, 1970; Baker & Dutt, 1972; Mazess, 1975; Abelson, 1976) that altitude has some adverse effect on fecundity and fertility, though the mechanism is not clear. Experimental studies on rats suggest that spermatogenesis is adversely affected by hypoxic stress, and studies on human females indicate irregularities in the menstrual cycle and increases in spontaneous abortions. Altitude also may increase neonatal mortality, since the newborns at high altitude have lower birth weights, and more are born prematurely. However, there is some discrepancy among the results of the studies in Latin America and elsewhere (Grahn & Kratchman, 1963; Baker & Dutt, 1972; Mazess, 1975; Abelson, 1976).

The results therefore in the present study are particularly interesting in that although no statistically significant differences between the high and low altitude Sherpas are detectable with regard to age-sex structure and mortality, there is a suggestion of reduced fertility in the high altitude sample in several of the measures employed. Besides the significant reduction in the mean completed family size and number of live births per married woman, trends in the same direction are seen in the number of live births per mother over 30, the average number of live births, and the total fertility rate. This is apparently not due to any difference in sterility, since the numbers of married women never pregnant are quite similar in the two samples and, if anything, higher in the Kalimpong group.

Our findings agree with those obtained in the Andean studies, in which, while mortality does not seem to be related to altitude, fertility in general shows a negative relationship (Hoff & Abelson, 1976; Way, 1976). Long-term adaptation to the hypoxic environment has been suggested for the Upper Khumbu Sherpas with respect to their haemoglobin level (Morpurgo *et al.*, 1976) which is much lower than in other high altitude populations and closer to some plains groups, and which is interpreted as indicating a different physiological mechanism of adaptation from other high altitude populations. It may be suggested analogously that due to their long-standing exposure to the high altitude milieu, the Upper Khumbu Sherpas have developed some mechanisms whereby the adverse effects of the environment, especially on infant and adolescent survival, are adequately counteracted. Thus they are able to survive without excessive fertility. Or it may be that their fertility has not yet reached such an adaptation, or that it is the lower altitude Kalimpong group in which the fertility pattern has altered. Finally, the differences may perhaps be simply ascribed to chance, for the samples are indeed small. But certainly the present study has drawn attention to a curious problem of a possible fertility difference, to the establishment and explanation of which it would be well worthwhile to devote considerable effort.

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References

- ABELSON, A.E. (1976) Altitude and fertility. *Hum. Biol.* **48**, 83.
- BAKER, P.T. & DUTT, J.S. (1972) Demographic variables as measures of biological adaptation: a case study of high-altitude human populations. In: *The Structure of Human Populations*. Edited by G. A. Harrison and A. J. Boyce. Clarendon Press, Oxford.
- CRUZ-COKE, R. (1977) A genetic description of high-altitude population. In: *The Biology of High-altitude Peoples*. Edited by P. T. Baker. Cambridge University Press, Cambridge.
- EATON, J.W. & MAYER, A.J. (1953) The social biology of very high fertility among the Huttenites: the demography of a unique population. *Hum. Biol.* **25**, 206.
- GRAHN, D. & KRATCHMAN, J. (1963) Variations in neonatal death rate and birth weight in the United States and possible relations to environmental radiation, geology, and altitude. *Am. J. hum. Genet.* **15**, 329.
- HAIMENDORF, C. VON F. (1964) *The Sherpas of Nepal*. Oxford Book Company, Calcutta.
- HOCK, R.J. (1970) The physiology of high altitude. *Sci. Am.* **22**, 52.
- HOFF, C.J. & ABELSON, A.E. (1976) Fertility. In: *Man in the Andes: a Multidisciplinary Study of High Altitude Quechua*. Edited by P. T. Baker and M. A. Little. Dowden, Hutchinson and Ross, Stroudsburg.
- MAZESS, R.B. (1975) Human adaptation to high-altitude. In: *Physiological Anthropology*. Edited by A. Damon. Oxford University Press, Oxford.
- MORPURGO, G., ARESE, P., BOSIA, A., PESCARMONA, G.P., LUZZANA, M., MODIANO, G. & KRISHNA RANIT, S. (1976) Sherpas living permanently at high-altitude: a new pattern of adaptation. *Proc. natn. Acad. Sci. USA*, **73**, 747.
- OPFITZ, M. (1974) Myths and facts: reconsidering some data concerning the clan history of the Sherpas. *Kailash*, **2**, 121.
- ROBERTS, D.F. (1956) A demographic study of a Dinka village. *Hum. Biol.* **28**, 323.
- WAY, A.B. (1976) Morbidity and postneonatal mortality. In: *Man in the Andes: a Multidisciplinary Study of High Altitude Quechua*. Edited by P. T. Baker and M. A. Little. Dowden, Hutchinson and Ross, Stroudsburg.