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HAEMOGLOBINOPATHIES IN THE INDIAN SUBCONTINENT

A Review of Literature

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SUMMARY

An up-to-date review of literature on the distribution of haemoglobinopathies in the Indian subcontinent has been presented. Haemoglobins S, D, E, J, K, L, M, Q, β-thalassaemia major, β-thalassaemia minor, α-thalassaemia minor, haemoglobin H, haemoglobin Lepore and persistence of foetal haemoglobin have been reported from India. β-thalassaemia in combination with haemoglobins S, E, D, J, K, Q has also been reported. Haemoglobin S is found to be prevalent among tribal populations in various regions of India, while haemoglobin D is prevalent among Sikhs, Pathans and Gujratis. Haemoglobin E is present in high frequency among populations of Assam, Bengal and Veddahs of Ceylon. β-thalassaemia major is widespread in various populations. There is paucity of data regarding distribution of β-thalassaemia minor and α-thalassaemias in this region.

The Indian subcontinent is a vast reservoir of abnormal haemoglobins and thalassaemias. Several of the abnormal haemoglobins were first detected in persons of Indian origin, e.g., Hbs D, J, K, and L, and prevalence of abnormal haemoglobins is widespread in many of the racial and tribal groups of India over wide areas. However, the only available reviews on the distribution of haemoglobinopathies in the Indian subcontinent is that of Chatterjea (1966) and of Livingstone (1967) as part of a study of the world distribution of abnormal haemoglobins. Since then, many reports have appeared in the literature and because of the medical and scientific significance of haemoglobinopathies it is desirable to present an up-to-date review of the subject.

The results of all the published surveys have been presented in tabular form according to geographical areas arranged in alphabetical order. The accompanying map shows the different States of the Indian subcontinent with capital cities (shown by solid square) and other relevant places (shown by solid circle). Isolated case reports and the most important points of the table have been described in the text under the headings for appropriate haemoglobins.

Haemoglobin S

The first case of sickle-cell anaemia in an Indian was reported from Capetown by Berk and Bull (1943). The patient was an anaemic married woman aged 22 years, born of Indian parents in Durban. The first cases in India itself were reported by Dunlop and Mozumder

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(1952) who found 5 cases of sickle-cell trait and 3 presumptive cases of sickle-cell anaemia among tea garden labourers of upper Assam, originating from the tribal population of Orissa and Bihar.

In the same year the presence of sickle-cell trait among the aboriginal tribes (the Pre-Dravidians) of the Nilgiri Hills was reported by Lehmann and Cutbush (1952). After that there have been several surveys in the Nilgiris by Lehmann's group and others and in other areas. The details of these surveys have been presented in the table.

High frequencies of the sickle-cell gene have been found in tribal population of the Nilgiris, and in several tribes of Gujrat, Madhya Pradesh, and Orissa. There are wide variations of the frequencies in different tribes in the same locality. Foy et al. (1956) reported 55% sickle-cell positive among Parja Kondhs and 3% among Jijmor Kondhs in South India. The details have not been published.

In contrast to the tribal populations the sickle-cell gene is almost absent in the different caste groups of India over the wide areas screened: thre are in general only sporadic instances of sickle-cell anaemia in the caste populations which may be due to occasional admixture of tribal blood. Sur et al. (1968) recorded 65 cases of sickle-cell haemoglobinopathy among children at Nagpur between 1962 and 1966: the highest incidence was among Neo-Buddhists. Several other sporadic instances of sickle-cell gene have been reported from all over the sub-continent (Shukla and Parande 1956, Nail et al. 1957, Shukla et al. 1958, Khandelwal and Paithankar 1961, Beohar et al. 1963, Salgia et al. 1965, Reddy and Baruah 1966, Reddy et al. 1966, Nanda et al. 1967, Subbarao et al. 1968, Praharaj et al. 1969, Rao et al. 1969, Guha and Bhattacherjee 1971). However, there are a few pockets of high frequencies of the sickle-cell gene reported among the caste groups: Sorathis (30%) in Gujrat, Danukhs (10.5%) in Uttar Pradesh, and Mahars (20%) in Madhya Pradesh, although the Mahars of Bombay have a much lower frequency of the gene (2%).

From the above it is clear the sickle-cell gene is widespread among many of the tribal populations of India, and is not unknown among the caste-groups of Indians. Further work is needed to have more systematic data for the different caste groups from all parts of the country.

Haemoglobin D

Bird et al. (1955) recorded the first case of Hb D in a 19-year-old Sikh soldier from the Hosiarpur district of East Punjab. Since then several surveys have been carried out, and Sikhs and Punjabi Hindus have been found to have Hb D with a frequency between 1 and 2%. In addition Hb D has been reported among Lohanas of Gujrat (1%), Gujratis (< 1%), Muslims of Bombay (0.2%), and among Indians in Goa and Due (very low). Pathans have been reported to have 1.4% of Hb D. Brahuis and Baluchis of N.W. Pakistan also have been reported to have D haemoglobin. Ghai et al. (1961) recorded D haemoglobin in a Punjabi family and Lele et al. (1962) recorded one case in a Kunbi family in Aurangadabad. Sporadic cases have been reported among Brahmins and Vaidyas of Bengal, Tamil Muslims, and from unspecified population groups in Mysore and Uttar Pradesh.

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Haemoglobin E

Hb E was first discovered simultaneously in Thais by Chernoff et al. and in a Guatemalan by Itano et al. in 1954. Hb E is widespread in S.E. Asian regions, with highest incidence in Thailand. High frequency of this haemoglobin is found in the eastern wing of India: Ahoms, Khasis, Assamese, and Totos, have frequencies ranging from 58 to 20%. Bhutanese have a frequency of 6.5%. Hb E is present among Bengalee Hindus (3%) and Bengalee Muslims (4%). It seems that there is a lower frequency of Hb E among Bengalee Brahmins compared to Kayasthas. Veddahs of Ceylon have also a high incidence of Hb E (17%). Sporadic instances of Hb E have been reported from Uttar Pradesh, and among Tamils and Malayalis of Singapore and Malaya. Cases of Hb E have also been reported among Sinhalese of Ceylon (Nagaratnam et al. 1958, De Silva et al. 1959) and in Bombay (Udani et al. 1963). Punt and Goel (1957) recorded two instances of Hb E in Indo-Europeans.

It appears from the above that Hb E is more prevalent among people of Eastern India, although it is not unknown in other areas. More systematic study is necessary of the distribution of Hb E in South India.

Haemoglobin J

Raper (1957) reported the first case of Hb J in a Gujrati woman in a survey of 500 Gujrati residents in Uganda. Sanghvi et al. (1958) recorded two cases of Hb J in 2 unrelated women belonging to the Gujrati-speaking Lohana community in Bombay, one of which was associated with thalassaemia trait. Vella (1962*a*) reported one instance of Hb J in a Sikh from a survey of 3341 Indians in Singapore. Subhedar et al. (1961) reported one case of Hb J in a Harijan family from Nagpur. Swarup et al. (1966*b*) reported Hb J in a Bengalee family in which there were two more instances of Hb J.

Haemoglobin K

Ager and Lehmann (1957*a*) reported the first case of Hb K in two unrelated East Indians in London. Vella (1962*a*) reported 5 cases of Hb K among 3341 Indians surveyed in Singapore. Labie et al. (1961) recorded 3 cases of Hb K among 114 Hindus of lower caste and another of unknown identity in Pondicherry. De Traverse et al. (1963) reported 3 instances of Hb K among 101 South Indians in Madras. Trincão et al. (1963) reported 2 instances of Hb K in a survey of 1843 Indians in Goa.

Haemoglobin L

Haemoglobin L was first reported by Ager and Lehmann (1957*b*) in a Punjabi Hindu of Kshatri caste resident in London. Vella (1962*a*) reported 2 instances of Hb L from Singapore, one in a Sindhi and the other in a Sikh. Sukumaran et al. (1959) reported 8 instances of Hb L in three Gujrati-speaking Lohana families in Bombay.

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Haemoglobin M

Only one family with haemoglobin M has so far been detected, in a Punjabi family from Amritsar (Chatterjea 1966). Three members of the family were found to have Hb M levels of 7%, 33%, and 50%.

Haemoglobin Q

Trincão et al. (1963) reported 4 instances of Hb Q in a survey of 1843 Indians in Goa. Sukumaran et al. (1971) recorded a new Hb $Q^{\alpha 64}$ (aspartic acid→histidine), or Hb Q (India), in two Sindhi families in Bombay.

THALASSAEMIA SYNDROMES

The earliest case of thalassaemia in India was reported by M. Mukherji (1938) in a two-and-a-half-year-old Bengalee boy from Calcutta. Due to lack of diagnostic facilities it was not possible to know whether the boy was suffering from thalassaemia major or E-thalassaemia. Since then until the early sixties, the literature on thalassaemia in India contained only a few scattered case reports of thalassaemia from various parts (Coelho 1939, Napier et al. 1939, Patel and Bhende 1939, Dhayagude 1944, Malhotra and Chhuttani 1944, K.C. Chaudhuri 1947, Chanda and Chaudhuri 1950, Pirzada and Kapoor 1950, De Silva and Weeratungee 1951, Tiagi et al. 1954, Ganguli and Lahiri 1955, Coelho et al. 1958, Das Gupta et al. 1958, Narayanappa 1963, and Srinivasan et al. 1966).

β-THALASSAEMIAS

β-thalassaemia major. This condition is caused by the homozygous state of a mutant gene resulting in suppression of β-chain synthesis and is present throughout the country. Chatterjea (1966) recorded 190 cases of thalassaemia major among Hindus, consisting of 175 Bengalees, 5 Biharis, 6 Punjabis, 2 each of Oriahs and Sindhis, and also in 3 Bengalee Muslims. Sanghvi et al. (quoted by Chatterjea 1966) recorded 128 cases of thalassaemia major at the Tata Cancer Institute, Bombay. From the J.J. Group of Hospitals in Bombay 157 cases of thalassaemia major have been reported also (Chatterjea 1966). Sharma et al. (1963) recorded a further 80 cases of thalassaemia major in Bombay and the regional distribution was as follows: Gujratis 35, Maharashtrians 21, Sindhis 12, Goanese 9, Bengalee 1, Uttar Pradesh 1. Udani et al. (1961) reported 14 cases of thalassaemia among Lohanas. Mathur et al. (1962) and Atal and Mittal (quoted by Chatterjea 1966) reported cases of thalassaemia major in the local populations and among Punjabis and Sindhis in Uttar Pradesh. Mariswamy and Pierce (1959) reported 5 cases of thalassaemia major from Mysore. Weatherall and Vella (1960) reported one case of thalassaemia in a Gurkha family in Singapore.

β-thalassaemia minor. This is caused by the heterozygous state of a mutant gene resulting in suppression of β-chain synthesis and has been reported among Bengalees (26%), Sherpas

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(1%), Cutchhi Bhanushalis (44%), Sikhs (6%), higher and lower caste Hindus of Pondicherry (20% and 14%), Indians in Khartoum (32%). Flatz et al. (1972) recently reported the presence of this trait among Assamese (5%), Ahoms (1%), and Khasis (< 1%) in Assam.

α-THALASSAEMIAS

α-thalassaemia minor. This is caused by the heterozygous state of a mutant gene resulting in suppression of synthesis of α-chains. This is expressed as increased Hb Bart's in cord blood. Hb-Bart's has been reported to be present among Bengalees (4%), Maharashtrians (1%) (Chouhan et al. 1969), Indians in Singapore and Malaya (1-2%).

Haemoglobin H. This is probably produced by the interaction of two α-thalassaemia genes (WHO 1972). Brain and Vella (1958) reported one case of Hb H trait in a Nepalese woman in Singapore. Hb H was reported from India by Swarup et al. (1963) in a 19-year-old Bengalee Hindu. Saha and Banerjee (1971) reported two cases of Hb H trait among Malayalis, and one each among Tamils, Gujratis, and Sindhis in Singapore. Nagaratnam and Sukumaran (1967) reported one case of Hb H from Ceylon.

THALASSAEMIA WITH OTHER ABNORMAL HAEMOGLOBINS

S-thalassaemia. Chatterjea (1966) reported 15 cases of S-thalassaemia, 8 in Oriah Hindus, 1 each in Bengalee Hindu and Muslim, and 1 in a South Indian Hindu and 2 in Tamil Muslims. Sanghvi et al. and Parekh respectively recorded 16 and 6 cases of S-thalassaemia in Bombay (quoted by Chatterjea 1966). Mital et al. (1962) reported a high incidence of S-thalassaemia among Sorathis in Palghar (3.7%). Lele et al. (1962) recorded one family of S-thalassaemia in a survey of 100 students of scheduled caste in Aurangadabad.

E-thalassaemia. Chatterjea (1966) reported 526 cases of E-thalassaemia investigated in Calcutta among Indian Hindus and the regional distribution was as follows: Bengalees 508, Oriahs 10, Biharis 4, Assamese 2, Punjabi 1, South Indian 1, and 48 cases among Bengalee Muslims and 1 in a Bihari Muslim. Khaleque (1961) reported one family with E-thalassaemia in Bangladesh. Sarkar et al. (1959) reported 14 cases of E-thalassaemia from Calcutta. Sanghvi et al. recorded 5 instances of E-thalassaemia in Bombay (quoted by Chatterjea 1966). Occasional cases have been reported from Uttar Pradesh. Kochhar and Kathpalia (1963) and Praharaj et al. (1969) reported solitary instances of E-thalassaemia in a Canarese and an Oriah family.

D-thalassaemia. Chatterjea (1966) reported 9 cases of D-thalassaemia - 6 from Bengal, and 1 each from Bihar, Punjab, and South India. Sanghvi et al. recorded 7 cases of D-thalassaemia in Bombay (quoted by Chatterjea 1966). Occasional cases of D-thalassaemia have been reported in and around Delhi (Ghai et al. 1961). Lele et al. (1962) reported one case in a Kunbi family from Aurangadabad. Sukumaran et al. (1960) reported one case each in a Sindhi and Gujrati-Lohana family.

J-thalassaemia. Sanghvi et al. (1958) recorded one case of J-thalassaemia in a Gujrati-speaking Lohana. Swarup et al. (1966*b*) reported 4 cases of J-thalassaemia in Bengalee Hindus.

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K-thalassaemia. Swarup et al. (1966*a*) reported an interaction of Hbs E and K with thalassaemia in a Bengalee family of Calcutta.

Q-thalassaemia. Sukumaran et al. (1972) recorded one case of Q-thalassaemia major and 2 cases of Q-thalassaemia minor in Sindhi families in Bombay.

Hereditary Persistence of Foetal Haemoglobin

Sukumaran et al. (1961) recorded 13 instances of this variant in heterozygous form, out of which in 3 they found double heterozygous state, i.e., Hb F and thalassaemia major. Similar interaction was observed in two Bengalee families by Chatterjea (1966) and by Barkhan and Adinolfi (1962) in a family of mixed Indian and Portuguese ancestry in London, by Parekh et al. (1963) in Indian families in Bombay, and by Bird et al. (1964) in an Indian boy at Poona.

Haemoglobin Lepore

Chouhan et al. (1971) reported the only case of Hb Lepore in an Indian family from Coondapur of Mysore state. Out of 23 members of the family, 10 had between 7.9% and 14.2% of this haemoglobin.

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FIGURE. *The Indian Subcontinent* [*showing different states with state capitals* (■) *and other relevant places* (●)].

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TABLE

DISTRIBUTION OF SICKLING TRAIT AND ABNORMAL HAEMOGLOBINS IN THE INDIAN SUBCONTINENT

Reference	Population	Locality	No. tested	No. with positive sickling or Hb-S	No. with other abnormal haemoglobins[a]
ANDHRA PRADESH					
Lehmann & Cutbush 1952	Telegus	Unspecified	109	0	—
Chaudhuri et al. 1964*a*	Chenchus	Unspecified	9	0	0
ASSAM, NEPAL, TIBET					
Chaudhuri et al. 1964*a*	Totos	Totopara, Assam	116	0	AE-23
Pande et al. 1970	Assamese	Poona	8	0	AE-1, EE-1
Das B.M. et al. 1971	Khasis	Assam	80	0	AE-31, EE-2
	Ahoms	Assam	82	0	AE-37, EE-11
Flatz et al. 1972	Assamese	Assam	182	0	AE-29, EE-5, Thal. minor-10
	Ahoms	Assam	129	0	AE-60,EE-15, Thal. minor-2
	Khasis	Assam	140	0	AE-51, EE-6, Thal. minor-4
	Kacharis	Assam	5	0	AE-4, EE-1
Aksoy et al. 1955	Nepalese	Poona	199	0	0
Bird et al. 1957	Gurkhas	Nepal	200	0	0
Vella & Field 1958	Gurkhas	Singapore	560	0	AE-3
Chatterjea 1959	Nepalese	Calcutta	109	0	AE-1
Lehmann 1959	Nepalese	Unspecified	99	0	0
Nijenhuis 1963	Nepalese	Pokhara, Nepal	14	0	0
	Tibetans	Nepal	47	0	0
Swarup et al. 1966*c*	Nepalese	Calcutta	134	0	High A_2-40
Glasgow et al. 1968	Bhutanese	Luana & Thimphu, Bhutan	31	0	AE-2
Jackson et al. 1960	Sherpas	Khembu, Tibet	128	0	AE-1, Thal. minor-1
BENGAL (WEST BENGAL & BANGLADESH)					
Buchi 1955*a*	Indians	Calcutta	400	0	—
Chatterjea et al. 1957	Bengalees	Calcutta	700	0	AE-25, EE-2, Thal.minor-26
Swarup et al. 1965	Bengalees (cord blood)	Calcutta	100	0	Bart's-4
Chaudhuri et al. 1969	Brahmins	Calcutta	235	0	0
	Kayasthas	Calcutta	229	0	AE-6
	Vaidyas	Calcutta	129	0	AE-1
Bhattacharjee 1956	Rahri Brahmins	Hooghly	100	0	—
	Muslims	Hooghly	100	0	—

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TABLE - *continued*

Reference	Population	Locality	No. tested	No. with positive sickling or Hb-S	No. with other abnormal haemoglobins[a]
Kumar 1957	Duley Bagdis	Hooghly	69	0	—
	Tentulia Bagdis	Hooghly	89	0	—
Chaudhuri et al. 1964*b*	Santals	Midnapore	119 families	2 (AS)	0
Chaudhuri et al. 1967*a*	Santals	Midnapore	336	4 (AS)	0
Das et al. 1967	Rajbanshis	Midnapore, Jalpaiguri, Cooch Bihar	300	0	—
	Padmaraj (Pods)	24-Parganas	100	0	—
	Mahishyas	24-Parganas	60	0	—
Chaudhuri et al. 1963	Anglo-Indians	Kharagpur	89	0	—
Pande et al. 1970	Bengalees	Poona	65	0	AE-1
Swarup et al. 1958[b]	Bengalee Muslims	Bangladesh	424	1	AE-25, E-thal.-50, S-thal.-1
Lehmann et al. 1961	Bengalee Muslims	Karachi	23	0	AE-2
Sen 1960	Brahmins	U.K.	188	0	AE-1, EE-1, AD-1, E-thal.-1
	Kayasthas	U.K.	269	0	AE-7
	Vaidyas	U.K.	88	0	AD-1
	Miscellaneous	U.K.	57	0	AE-2
Pande et al. 1972	Bengalees	Unspecified	41	0	AE-1
BIHAR					
Lehmann 1954	Oraons	Bihar	100	0	—
	Kharias	Bihar	23	0	—
Chatterjea 1959	Biharis	Calcutta	54	0	0
Kirk et al. 1962*a*	Oraons	Chota Nagpur	56	0	0
Pande et al. 1970	Biharis	Poona	57	0	0
Pande et al. 1972	Biharis	Unspecified	25	0	0
GUJRAT					
Sukumaran et al. 1956	Anavil Brahmins	Surat	53	0	—
	Leva Patidars	Kheda	150	0	—
Mital et al. 1962	Sorathis	Palghar	325	99 (AS-81, SS-6)	S-thal.-12
Sanghvi 1962	Brahmins	Gujrat	203	0	0
	Lohanas	Gujrat	603	0	AD-5, AJ-2, AL-3
Vyas et al. 1962	Bhils	Panchmahal	206	32 (AS)	0
	Gamils	Surat	207	65 (AS-26[c], SS-2)	0

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TABLE - *continued*

Reference	Population	Locality	No. tested	No. with positive sickling or Hb-S	No. with other abnormal haemoglobins[a]
Vyas et al. 1962 (*contd.*)	Dublas	Surat	211	20 (AS)	0
	Kolis	Surat	182	8 (AS)	0
	Naikas	Surat	174	28 (AS-26[c])	0
	Dhodias	Surat	213	38 (AS)	
	Dhankas	Broach	215	44 (AS-41, SS-3)	0
Sayed & Amin 1966	Bhils	Baroda	220	38	—
Jacob et al. 1956	Gujratis	Uganda	326	0	AD-1
Raper 1957	Gujratis	Uganda	500	0	AD-4, AJ-1
KERALA					
Lehmann & Cutbush 1952	Malayalis	Unspecified	110	0	—
Bird et al. 1962	Malayalis	Poona	190	0	0
Chaudhuri et al. 1964*a*	Indians	Kerala	35	0	—
Buchi 1955*c*	Malapandarams	Quilon	116	0	—
	Kurubans	Quilon	36	0	—
	Ullatans	Quilon	142	0	—
	Malavedans	Quilon	69	0	—
	Kadars	Trichur	167	0	—
Saha & Banerjee 1971	Malayalis	Kerala & Singapore	314	0	AE-2, AH-1
MADHYA PRADESH					
Negi 1962	Dorlas	Konta (Bastar)	200	26	—
	Dhurwas	Jagdalpur (Bastar)	218	7	—
	Northern Dhurwas	Jagdalpur	60	10	—
Negi 1963	Bade Bhattras	Jagdalpur	153	25	—
	Manjhela Bhattras	Jagdalpur	64	7	—
	San Bhattras	Jagdalpur	88	17	—
	Mahars	Jagdalpur	123	47	—
	Eastern Murias	Kondagaon (Bastar)	143	15	—
	Western Murias	Kondagaon	169	27	—
Negi 1964	Marias (Bison-horned)	Bijapur (Bastar)	185	29	—
	Raj Gonds	Bastar	68	8	—
	Dorlas	Bastar	27	3	—
	Halbas	Bastar	34	9	—
	Mahars	Bhopalpatnam (Bastar)	30	12	—
	Telangas (Telegu)	Bastar	19	0	—
	Others	Bastar	34	3	—

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TABLE - *continued*

Reference	Population	Locality	No. tested	No. with positive sickling or Hb-S	No. with other abnormal haemoglobins[a]
Kumar 1966	Bhils	Indore	46	11	—
	Balais	Indore	73	4	—
	Chamars	Indore	22	2	—
	Others	Indore	95	0	—
Das et al. 1967	Balais	Unspecified	104	5	—
	Bhilalas	Unspecified	139	39	—
	Bhils	Unspecified	174	21	—
Kumar & Ghosh 1967	Mehtars	Ujjain	72	1	—
	Brahmins	Ujjain	28	0	—
	Rajputs	Ujjain	42	0	—
	Jains & Vaishyas	Ujjain	15	0	—
	Dhakars	Dewas	25	0	—
	Nayata Muslims	Ujjain & Dewas	65	1	—
	Chamars	Ujjain & Dewas	27	0	—
	Muslims	Ujjain & Dewas	12	0	—
	Balais	Ujjain & Dewas	10	0	—
	Others	Ujjain & Dewas	17	0	—
Sharma 1968	Raj Gonds	Bastar	54	15	—
	Murias	Bastar	35	10	—
	Bhattras	Bastar	25	7	—
	Halbas	Bastar	26	6	—
Pande et al. 1970	Indians	Poona	67	1 (AS)[d]	0
Pande et al. 1972	Indians	Unspecified	34	0	AD-1
MAHARASHTRA					
Shukla & Solanki 1958	Mahars	Nagpur	450	100 (AS)[e]	—
	Kunbis	Nagpur	116	11 (AS)[e]	—
	Telis	Nagpur	89	9 (AS)[e]	—
	Koshtis	Nagpur	46	0	—
	Ghonds	Nagpur	53	0	—
	Muslims	Nagpur	68	0	—
	Brahmins	Nagpur	26	0	—
	Others	Nagpur	171	0	—
Das et al. 1961	Mahars	Nagpur	482	87	—
Lele et al. 1962	Scheduled caste	Aurangadabad	700	39 (AS-36, SS-2)	S-thal.-1
Sanghvi 1962	Marathas	Maharashtra	201	0	0
	Gurjars	Maharashtra	203	0	0
	Pajnas	Maharashtra	200	0	0
	Chamars	Maharashtra	208	0	0
	Mahars	Maharashtra	200	4 (AS)	0
	Mixed	Maharashtra	222	0	0

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TABLE - *continued*

Reference	Population	Locality	No. tested	No. with positive sickling or Hb-S	No. with other abnormal haemoglobins[a]
Sanghvi 1962 (*contd.*)	Thakurs	Maharashtra	264	0	0
	Koknas	Maharashtra	190	8 (AS)	0
	Katkaris	Maharashtra	262	21 (AS)	0
	Warlis	Maharashtra	225	36 (AS)	0
Deshmukh 1968	Mahars	Aurangadabad	100	24 (AS)	0
Parikh et al. 1969*b*	Mahars	Bombay	200	0	0
Parikh et al. 1969*a*	Audich Brahmins	Bombay	200	0	0
	Lad Vanias	Bombay	200	0	0
	Visa Oswal Jains	Bombay	200	0	0
Undevia 1969	Parsis	Bombay	1290	5 (AS)	0
	Iranis	Bombay	160	0	0
Baxi et al. 1970	Scavengers	Bombay	140	0	0
Pande et al. 1970	Maharashtrians	Poona	355	5 (AS)[f]	0
Hakim et al. 1972	Muslims	Bombay	854	0	AD-2
Mehta et al. 1972	Cutchhi Bhanushali	Bombay	599	9	High A_2-44
Pande et al. 1972	Indians	Unspecified	34	0	0
MYSORE					
Lehmann & Cutbush 1952	Canarese	Unspecified	95	0	—
Swarup et al. 1959	Indians	Shimoga	550	1	0
		Unspecified	68	1 (AS)	AD-1
ORISSA					
Batabyal & Wilson 1958	Oriahs	Assam	100	15	—
	Griza Oriahs	Assam	100	29	—
Das et al. 1967	Bado Gadabas	Koraput	99	0	—
	Pareng Gadabas	Koraput	225	28	—
	Ollaro Gadabas	Koraput	225	6	—
	Bareng Porojas	Koraput	104	0	—
	Konda Porojas	Koraput	225	30	—
Roy & Roy Chaudhuri 1967	Tribals	Koraput	770	86	—
	Tribals	Umerkote	630	64	—
	Tribals	Kondaga	73	5	—
PUNJAB, HARYANA & KASHMIR					
Aksoy et al. 1955	Sikhs	Poona	100	0	0
Siddoo et al. 1956	Sikhs	Vancouver	80	0	Thal.minor-5
Bird et al. 1956	Sikhs	N.W.India	279	0	AD-4, DD-1
Bird & Lehmann 1956	Hindus	N.W. India	13	0	AD-1
Saha & Banerjee 1965	Sikhs	Ludhiana	100	0	AD-1, Thal. major-1
Chaudhuri et al. 1967*b*	Sikhs	Calcutta	427	0	AD-5, AE-1

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TABLE - *continued*

Reference	Population	Locality	No. tested	No. with positive sickling or Hb-S	No. with other abnormal haemoglobins[a]
Pande et al. 1970	Sikhs	Poona	117	0	0
	Hindus	Poona	50	0	0
	Others	Poona	70	0	0
	Jats	Poona	41	0	0
Saha & Banerjee 1971	Sikhs	Punjab, Singapore	378	0	AD-5, DD-1
	Hindus	Singapore	123	0	AD-1
Mathur et al. 1962	Punjabis	Agra	11	0	Thal.major-2
Pande et al. 1972	Punjabis & Kashmiris	Unspecified	66	0	AD-1
TAMILNADU					
Lehmann & Cutbush 1952	Tamils	Unspecified	128	0	—
Labie et al. 1961	Higher caste	Pondicherry	28	0	High A_2-5
	Lower caste	Pondicherry	114	0	High A_2-16, AK-3
	Untouchables	Pondicherry	11	0	0
	Nairs	Pondicherry	3	0	0
	Kharwars	Pondicherry	1	0	0
	Muslims	Pondicherry	1	0	0
	Unknown	Pondicherry	12	0	High A_2-2, AK-1
De Traverse et al. 1963	Indians	Madras city	101	0	AK-3
Wickremasinghe et al. 1963*b*	Tamils	Ceylon	660	0	0
	Muslims	Ceylon	252	0	0
Saha & Banerjee 1971	Tamils	Kerala & Singapore	1310	0	AE-6, EE-2, AH-2, AD-1
Lehmann 1954	Paniyans	Nilgiri	61	21	—
	Kurumbas	Nilgiri	16	3	—
	Kotas	Nilgiri	86	0	—
	Irulas	Nilgiri	124	39	—
	Badagas	Nilgiri	191	26	—
	Todas	Nilgiri	84	3	—
Buchi 1955*a*	Paniyans	Wynad, Nilgiri	74	22	—
Buchi 1955*b*	Pallars	Tinnevelly	112	1	—
Lehmann & Sukumaran 1956	Kurumbas	Nilgiri	26	7 (AS)	0
	Kotas	Nilgiri	22	0	0
	Badagas	Nilgiri	30	2 (AS)	0
	Todas	Nilgiri	50	1 (AS)	0
	Irulas	Nilgiri	18	4 (AS)	0
Buchi 1959	Kurumbas	Nilgiri	112	20	—
Kirk et al. 1962*b*	Kurumbas	Nilgiri	43	10 (AS)	0
	Irulas	Nilgiri	15	6 (AS)	0

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TABLE - *Continued*

Reference	Population	Locality	No. tested	No. with positive sickling or Hb-S	No. with other abnormal haemoglobins[a]
Kirk et al. 1962*b* (*contd.*)	Todas	Nilgiri	60	2 (AS)	0
Das et al. 1967	Paniyans	Wynad, Nilgiri	955	265	—
Chaudhuri et al. 1964*a*	Kotas	Nilgiri	12	0	—
	Todas	Nilgiri	12	0	—
UTTAR PRADESH					
Bhatia et al. 1955	Dhanukh caste	Mainpur	335	32	—
Dube et al. 1959	Indians	Lucknow	235	0	0
Misra 1961	Indians	Agra	250	0	0
Mathur et al. 1962	Indians	Agra	410 (anaemic)	0	AE-1, Thal.major-6, Thal.minor-1
	Indians	Western U.P.	102	0	0
Atal. & Mital 1966[b]	Indians	U.P.	97	0	Thal.major-2, AE-1
Mehrotra et al. 1968	Indians	U.P.	755	0	AD-2, AE-1
Pande et al. 1970	Indians	Poona	352	0	0
Gupta et al. 1970	Indians	Allahabad	1270	0	E-thal.-1
Pande et al. 1972	Indians	Unspecified	193	0	0
ANDAMANS					
Lehmann 1954	Andamanese	Andaman	16	0	—
	Onges	Little Andaman	52	0	—
Agrawal 1968	Nicobarese	Great Nicobar	113	0	—
GOA, DAMAN, DIU					
Lessa & Dessai 1955	Indians	Goa	684	0	—
Trincão et al. 1963	Indians	Goa	1843	0	AD-5, AK-2, AQ-4
	Indians	Goa	833	0	High F-20
	Indians	Diu	379	1 (AS)	AD-2
CEYLON					
De Silva 1957	Ceylonese	Colombo	800	0	0
Wickremasinghe et al. 1963*b*	Sinhalese	Ceylon	1068	0	0
	Burghers	Ceylon	60	0	0
Graff et al. 1954	Veddahs	Ceylon	9	0	AE-2
Aksoy et al. 1955	Veddahs	Ceylon	158	0	AE-3
Kirk et al. 1962*b*	Veddahs	Ceylon	30	0	AE-14, EE-2
Wickremasinghe et al. 1963*a*	Veddahs	Pollebedda, Central Ceylon	38	0	AE-4, EE-1

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TABLE - *Continued*

Reference	Population	Locality	No. tested	No. with positive sickling or Hb-S	No. with other abnormal haemoglobins[a]
Wickremasinghe et al. 1963*a* (*contd.*)	Veddahs	Dambana, Central Ceylon	27	0	0
	Veddahs	Ginidamana, Central Ceylon	87	0	AE-26, EE-2
	Veddahs	Adampane, Northern Ceylon	32	0	AE-5
PAKISTAN					
Lehmann et al. 1961	West Pakistanis	Karachi	76	1 (AS)	0
Mathur et al. 1962	Sindhis	Agra	43	0	Thal.major-2
Bolton et al. 1964	Brahuis	N.W. Pakistan	4	0	AD-1
	Sindhis	N.W. Pakistan	6	0	AJ-1
	Baluchis	N.W. Pakistan	9	0	AD-2
	Pathans	N.W. Pakistan	18	0	AJ-2, JD-1
	Others	N.W. Pakistan	18	0	0
Stern et al. 1968	Pathans	N.W. Pakistan	129	0	AD-1, Thal.minor-5
UNSPECIFIED					
Lie-Injo & Ti 1961	Indians (cord blood)	Kuala Lumpur	278	0	Bart's-3
Vella 1962*a*	Indians	Singapore & Malaya	3341	0	AD-15, AE-15, AL-2, AJ-1, AK-5
	Indians (cord blood)	Singapore & Malaya	222	0	Bart's-2
Vella 1962*b*	Indians	Khartoum	31	0	High A_2-10
Pande et al. 1970	South Indians	Poona	135	1 (AS)	0
Saha 1970	Indians	Singapore	143	0	AD-2, AE-1
Lopez & Lie-Injo 1971	Indians (newborns)	Malaya	226	0	Bart's-4
Saha & Banerjee 1971	Gujratis & Sindhis	Singapore & Punjab	150	0	AD-1, AE-1, AH-1
Pande et al. 1972	South Indians	Unspecified	116	0	0

[a] The indication "—" stands for no electrophoresis performed.
[b] Unpublished observation quoted by Chatterjea 1966.
[c] Electrophoresis was not performed on the rest of the samples.
[d] The subject with AS belonged to Mahar caste.
[e] Electrophoresis was only performed on sickling-positive samples.
[f] Four belonged to Mahar caste and the other to Maratha caste.

https://doi.org/10.1017/S1120962300017650 Published online by Cambridge University Press

REFERENCES

Ager J.A.M., Lehmann H. 1957*a*. Haemoglobin K in an East Indian and his family. Br. Med. J., 1: 1449-1450.

Ager J.A.M., Lehmann H. 1957*b*. Haemoglobin L: a new haemoglobin found in a Punjabi Hindu. Br. Med. J., 2: 142-143.

Agrawal H.N. 1968. ABO blood groups, PTC sensitivity, sickle-cell trait, middle-phalangeal hairs and colour-blindness in the Coastal Nicobarese of Great Nicobar. Acta Genet. (Basel), 18: 147-154.

Aksoy M., Bird G.W.G., Lehmann H., Mourant A.E., Thein H., Wickremasinghe R.L. 1955. Haemoglobin E in Asia. J. Physiol. (Lond.), 130: 56P-57P.

Barkhan P., Adinolfi M. 1962. Observations on the high foetal haemoglobin gene and its interaction with thalassaemia gene. J. Clin. Pathol., 15: 350-356.

Batabyal J.N., Wilson J.M.G. 1958. Sickle cell anaemia in Assam. J. Indian Med. Assoc., 30: 8-11.

Baxi A.J., Shah R.C., Kulkarni K.V. 1970. Studies of blood groups and other genetical characters in "Scavenger" community of Bombay. Proc. Indian Soc. Haematol. Blood Transf. 1970.

Beohar P.C., Gupta D.K., Nivasarkar V.G. 1963. Sickle cell disease with leg ulcers. J. Indian Med. Assoc., 40: 495-497.

Berk L., Bull G.M. 1943. Case of sickle cell anaemia in Indian woman. J. Capetown Postgrad. Med. Assoc., 2: 147-152.

Bhatia H.M., Thin J., Debray H., Cabanes J. 1955. Étude anthropologique et génétique de la population du Nord de l'Inde. Bull. Soc. Anthropol. (Paris), 6: 199-213.

Bhattacharjee P.N. 1956. A genetic survey in the Rarhi Brahmins and Muslims of West Bengal: A_1-A_2-B-O, M-N, Rh blood groups, ABH secretion sickle cell, PTC taste, middle-phalangeal hairs and colour-blindness. Bull. Dept. Anthropol., Govt. of India, 5: 18-26.

Bird G.W.G., Lehmann H., Mourant A.E. 1955. A third example of haemoglobin D. Trans. R. Soc. Trop. Med. Hyg., 49: 399-400.

Bird G.W.G., Lehmann H. 1956. Haemoglobin D in India. Br. Med. J., 1: 514.

Bird G.W.G., Ikin E.W., Lehmann H., Mourant A.E. 1956. The blood groups and haemoglobins of the Sikhs. Heredity (Lond.), 10: 425-429.

Bird G.W.G., Jayaram T.K., Ikin E.W., Mourant A.E., Lehmann H. 1957. The blood groups and haemoglobins of the Gorkhas of Nepal. Am. J. Phys. Anthropol., 15: 163-169.

Bird G.W.G., Ikin E.W., Mourant A.E., Lehmann H. 1962. The blood groups and haemoglobins of the Malayalis. In T.N. Madan and G. Sarna (Eds.): Essays in Memory of D.N. Majumdar. Asia Publishing House, Bombay, pp. 221-226.

Bird G.W.G., Hasan M.I., Malhotra P.O., Lehmann H. 1964. Interaction of β-thalassaemia and hereditary persistence of foetal haemoglobin. J. Med. Genet., 1: 24-26.

Bolton J.P., Harrison B.D.W., Lehmann H. 1964. Abnormal haemoglobins in a small group of tribesmen from N.W. Pakistan. Man, 64: 113-114.

Brain M.C., Vella F. 1958. Haemoglobin H trait in a Nepalese Gurkha woman. Lancet, 1: 192-194.

Buchi E.C. 1955*a*. Is sickling a weddid trait? The Antropologist, 1: 25-29.

Buchi E.C. 1955*b*. Blood, secretion and taste among the Pallar, a South Indian community. The Anthropologist, 2,1: 1-8.

Buchi E.C. 1955*c*. A genetic survey among the Malapantaram, a hill tribe of Trivancore. The Anthropologist, 2,2: 1-11.

Buchi E.C. 1959. Blut, Geschmack und Farbensinn ber den Kurumba (Nilgiri, Südindoen). Arch. Julius Klaus Stift., 34: 310-316.

Chanda N.K., Chaudhuri K.C. 1950. Cooley's anaemia. Indian J. Pediatr., 17: 84-95.

Chatterjea J.B., Swarup S., Ghosh S.K., Ray R.N. 1957. Incidence of haemoglobin-E and « thalassaemia trait » in Bengalees. Bull. Calcutta Sch. Trop. Med., 5: 159-160.

Chatterjea J.B. 1959. Haemoglobinopathy in India. In J.H.P. Jonxis and J.F. Delafresnaye (Eds.): Abnormal Haemoglobins. Blackwell Scientific Publication, Oxford, pp. 322-339.

Chatterjea J.B. 1966. Haemoglobinopathies, glucose-6-phosphate dehydrogenase deficiency and allied problems in Indian subcontinent. Bull. WHO, 35: 837-856.

Chaudhuri K.C. 1947. Erythroblastic anaemia of Cooley. Indian J. Pediatr., 14: 76-80.

Chaudhuri S., Sen S.N., Mukherjee B., Ghosh J. 1963. Haematological field survey in Anglo-Indian communities of Kharagpore, West Bengal. J. Assoc. Physicians India, 11: 955-960.

https://doi.org/10.1017/S1120962300017650 Published online by Cambridge University Press

Chaudhuri S., Chakravartti M.R., Mukherjee B., Sen S.N., Ghosh J., Maitra A. 1964*a*. Study of haematological factors, blood groups, anthropometric measurements and genetics of some of the tribal and caste groups of: 1. South India - Kerala, Nilgiris and Andhra Pradesh; 2. North Eastern India - Totopara. Proc. 9th Congr. Int. Soc. Blood Transf. (Mexico), S. Karger, New York, pp. 196-205.

Chaudhuri S., Ghosh J., Mukherjee B. 1964*b*. Study of haemoglobin variants and blood groups in Santal tribe of Midnapore district of West Bengal, India. Abs. 10th Congr. Int. Soc. Haematol. (Stockholm, 1964), 1: 11.

Chaudhuri S., Ghosh J., Mukherjee B., Roychowdhury A.K. 1967*a*. Study of blood groups and haemoglobin variants among Santal tribe in Midnapore district of West Bengal, India. Am. J. Phys. Anthropol., 26: 307-311.

Chaudhuri S., Mukherjee B., Roychowdhury A.K., Ghosh J. 1967*b*. Study of blood groups and haemoglobin variants of the Sikhs of Calcutta. J. Hered., 58: 213-214.

Chaudhuri S., Mukherjee B., Ghosh J., Roychowdhury A.K. 1969. Study of blood groups, ABH secretors and haemoglobin variants in three upper castes of West Bengal, India. Am. J. Phys. Anthropol., 30: 129-132.

Chernoff A.I., Minnich V., Chongchareonsuk S. 1954. Haemoglobin E, a hereditary abnormality of human haemoglobin. Science, 120: 605-606.

Chouhan D.M., Sharma R.S., Parekh J.G. 1969. α-thalassaemia in India. 5th Congr. Asian and Pacific Soc. Haematol. (Istanbul).

Chouhan D.M., Sharma R.S., Vakil B.J., Parekh J.G. 1971. Haemoglobin lepore in an Indian family. J. Indian Med. Assoc., 56: 287-290.

Coelho G. 1939. Erythroblastic anaemia - Cooley's anaemia? Med. Bull. Bombay, 1: 291.

Coelho G., Setna S., Simmons S.C. 1958. Thalassaemia in Indian children. Indian J. Child Hlth., 7: 798-804.

Das B.M., Chakravartti M.R., Delbrück H., Flatz G. 1971. High prevalence of haemoglobin E in two populations in Assam. Humangenetik, 12: 264-266.

Das S.R., Kumar N., Bhattacharjee P.N., Sastry D.B. 1961. Blood groups (ABO, M-N and Rh), ABH secretion, sickle-cell, PTC taste and colour-blindness in the Mahars of Nagpur. J. R. Anthropol. Inst. (Gr. Brit.), 91: 345-355.

Das S.R., Mukherjee D.P., Sastry D.B. 1967. Sickle cell trait in Koraput district and other parts of India. Acta Genet. (Basel), 17: 62-73.

Das Gupta C.R., Chatterjea J.B., Ray R.N., Ghosh S.K., Chowdhury A.B. 1958. Observations on Cooley's anaemia (thalassaemia). Proc. 6th Int. Congr. Haematol., (Boston 1956), Grune and Stratton, New York.

De Silva C.C., Weeratungee C.E.S. 1951. Cooley's anaemia in Sinhalese children. Arch. Dis. Child., 26: 224-230.

De Silva C.C. 1957. Abnormal haemoglobins and haemoglobinopathies. J. Lady Ridgeway Hosp. Child., Colombo, 6: 16-32.

De Silva C.C., Jonxis J.H.P., Wickremasinghe R.L. 1959. Haemoglobinopathies in Ceylon. In: J.H.P. Jonxis and J.F. Delafresnaye (Eds.): Abnormal Haemoglobins. Blackwell Scientific Publication, Oxford, pp. 340-356.

De Traverse P.M., Coquelet M.L., Henrotte J.G. 1963. Anomalie de l'hémoglobine dans la population de Madras. C. R. Soc. Biol. (Paris), 157: 38-41.

Deshmukh V.V. 1968. Deficiency of erythrocyte glucose-6-phosphate dehydrogenase and sickle cell trait: a survey at Aurangabad, Maharashtra. Indian J. Med. Res., 56: 821-825.

Dhayagude R.G. 1944. Erythroblastic anaemia of Cooley (familial erythroblastic anaemia) in Indian boy. Am. J. Dis. Child., 67: 290-293.

Dube B., Kumar S., Mangalik V.S. 1959. Absence of abnormal haemoglobins in 235 subjects of Uttar Pradesh. Indian J. Med. Res., 47: 148-149.

Dunlop K.J., Mozumder U.K. 1952. The occurrence of sickle-cell anaemia among group of tea garden labourers of Upper Assam. Indian Med. Gaz., 87: 387-391.

Flatz G., Chakravartti M.R., Das B.M., Delbrück H. 1972. Genetic survey in the population of Assam. I. ABO blood groups, glucose-6-phosphate dehydrogenase and haemoglobin type. Hum. Hered., 22: 323-330.

Foy H., Brass W., Kondi A. 1956. Sickling and malaria. Br. Med. J., 1: 289-290.

Ganguli H., Lahiri S.C. 1955. Observations on Cooley's anaemia. J. Indian Med. Assoc., 24: 453-457.

Ghai O.P., Verma K.P.S., Taneja P.N. 1961. Haemoglobinopathies in North India. Haemoglobin D-thalassaemia. Indian J. Child Hlth., 10: 334-341.

Glasgow B.G., Goodwin M.J., Jackson F., Kopec A.C., Lehmann H., Mourant A.E., Tills D., Turner R.W.D., Ward M.P. 1968. The blood groups, serum groups and haemoglobins of the

https://doi.org/10.1017/S1120962300017650 Published online by Cambridge University Press

inhabitants of Luana and Thimbu, Bhutan. Vox. Sang., 14: 31-42.

Graff J.A.E., Lehmann H., Mourant A.E., Perkins D.M., Wickremasinghe R.L. 1954. Haemoglobin E and blood groups in the Veddahs. J. Physiol. (Lond.), 127: 41p.

Guha P., Bhattacherjee A.K. 1971. Abnormal haemoglobins in a coal miner and his family. J. Indian Med. Assoc., 57: 204-206.

Gupta S.C., Mehrotra T.N., Mehrotra V.G. 1970. Haemoglobin E-thalassaemia in Uttar Pradesh. Indian J. Med. Res., 58: 857-862.

Hakim S.M.A., Baxi A.J., Balakrishnan V., Kulkarni K.V., Rao S.S., Jhala H.T. 1972. Haptoglobin, transferrin and abnormal haemoglobins in Indian Muslims. Indian J. Med. Res., 60: 699-703.

Itano H.A., Bergren W.R., Sturgeon P. 1954. Identification of a fourth abnormal human haemoglobin. J. Am. Chem. Soc., 76: 2278.

Jackson F.S., Lehmann H., Sharih A. 1960. Thalassaemia in a Tibetan discovered during a haemoglobin survey among the Sherpas. Nature (Lond.), 188: 1121-1122.

Jacob G.F., Lehmann H., Raper A.B. 1956. Haemoglobin D in Indians of Gujerati origin in Uganda. East Afr. Med. J., 33: 135-138.

Khaleque R.A. 1961. Haemoglobin E, thalassaemia and their combination in a Muslim family of East Pakistan. J. Trop. Med. Hyg., 64: 171-174.

Khandelwal M.K., Paithankar M.T. 1961. Sickle cell anaemia in children. In S.K. Bose and A.K. Dey (Eds.): Asian Pediatrics. Asia Publishing House, Bombay, pp. 275.

Kirk R.L., Lai L.Y.C., Vos G.M., Vidyarthi L.P. 1962*a*. A genetic survey of the Oraons of the Chota Nagpur Plateau (Bihar, India). Am. J. Phys. Anthropol., 20: 375-385.

Kirk R.L., Lai L.Y.C., Vos G.M., Wickremasinghe R.L., Perara D.J. 1962*b*. The blood and serum groups of selected populations in South India and Ceylon. Am. J. Phys. Anthropol., 20: 485-497.

Kochhar B.R., Kathpalia P.M. 1963. Haemoglobin E-thalassaemia disease. Indian J. Med. Sci., 17: 138-142.

Kumar N. 1957. A genetic survey among the Tentulia Bagdi and Duley Bagdi of Hooghly district in West Bengal. Bull. Dept. Anthropol. Govt. India, 6: 81-88.

Kumar N. 1966. ABO blood groups and sickle cell trait investigations in Madhya Pradesh, Indore district, India. Acta Genet. Med. Gemellol. (Roma), 15: 404-408.

Kumar N., Ghosh A.K. 1967. ABO blood groups and sickle cell trait investigations in Madhya Pradesh, Ujjain and Dewas districts. Acta Genet. (Basel), 17: 55-61.

Labie D., Rosa J., Paviot J.J. 1961. Sur l'existence de différentes anomalies de l'hémoglobine dans une population du Sud de l'Inde. Nouv. Rev. Fr. Hematol., 1: 562-568.

Lehmann H., Cutbush M. 1952. Sickle cell trait in Southern India. Br. Med. J., 1: 404-405.

Lehmann H. 1954. Distribution of the sickle cell gene. Eugen. Rev., 46: 101-102.

Lehmann H., Sukumaran P.K. 1956. Examination of 146 South Indian aborigines for haemoglobin variants. Man, 56: 95-96.

Lehmann H. 1959. Distribution of variations in human haemoglobin synthesis. In J.H.P. Jonxis and J.F. Delafresnaye (Eds.): Abnormal Haemoglobins. Blackwell Scientific Publication, Oxford, pp. 202-215.

Lehmann H., Sharih A., Robinson G.L. 1961. Sickle cell haemoglobin in a Pathan. Man, 61: 108-109.

Lele R.D., Solanki B.R., Bhagwat R.B., Ingle V.N., Shah P.M. 1962. Haemoglobinopathies in Aurangabad region. J. Assoc. Physicians India, 10: 263-271.

Lessa A., Dessai M. 1955. Enquêtes sur la drépanocytose. Proc. 5th Int. Congr. Blood Transf. (Paris), pp. 507-508.

Lie-Injo L.E., Ti T.S. 1961. The fast-moving haemoglobin component in healthy newborn babies in Malaya. Med. J. Malaya, 16: 107-114.

Livingstone F.B. 1967. Abnormal Haemoglobins in Human Populations. Aldine Publishing Company, Chicago.

Lopez C.G., Lie-Injo L.E. 1971. α-thalassaemia in newborns in West Malaysia. Hum. Hered., 21: 185-191.

Malhotra R.C., Chhuttani P.N. 1944. A case of Cooley's anaemia. Indian Med. Gaz., 79: 198-199.

Mariswamy M.L., Pierce D.E.M. 1959. Thalassaemia in South India. J. Trop. Pediatr., 4: 147-150.

Mathur K.S., Mehrotra T.N., Dayal R.S., Yadav S.N.S. 1962. Incidence of haemoglobin E and thalassaemia in Uttar Pradesh. J. Indian Med. Assoc., 39: 172-177.

Mehrotra V.G., Gupta S.C., Pande S.R., Mehrotra T.N. 1968. Abnormal haemoglobins in Uttar Pradesh. Indian J. Med. Res., 56: 1365-1370.

Mehta B.C., Dave V.B., Joshi S.R., Baxi A.J., Bhatia H.M., Patel J.C. 1972. Studies of haema-

https://doi.org/10.1017/S1120962300017650 Published online by Cambridge University Press

tological and genetical characteristics of Cutchhi Bhanushali community. Indian J. Med. Res., 60: 305-311.

Misra G.M. 1961. A Study of Abnormal Haemoglobins Found in Western Uttar Pradesh. Thesis for M.D., Agra University.

Mital M.S., Parekh J.G., Sukumaran P.K., Sharma R.S., Dave P.J. 1962. A focus of sickle cell gene near Bombay. Acta Haematol. (Basel), 27: 257-267.

Mukherji M. 1938. Cooley's anaemia (erythroblastic or Mediterranean anaemia). Indian J. Pediatr., 5: 1-7.

Nagaratnam N. Wickremasinghe R. L., Jayawickrame U.S., Maheson V.S. 1958. Haemoglobin E syndrome in a Ceylonese family. Br. Med. J., 1: 866-868.

Nagaratnam J., Sukumaran P.K. 1967. Thalassaemia in Ceylon. Acta. Haematol. (Basel), 38: 209-218.

Nail S.K., Kothari B.V., Jhaveri C.L., Sukumaran P.K., Sanghvi L.D. 1957. Fatal hemolytic anaemia presumably due to the combination of sickle-cell and thalassaemic gene. Indian J. Med. Sci., 11: 244-249.

Nanda B.K., Panda G.K., Naik W.P., Nanda C.N., Praharaj K.C. 1967. Haemoblogin S in Acharia community in Orissa. J. Indian Med. Assoc., 48: 150-152.

Napier L.E., Shorten J.A., Das Gupta C.R. 1939. Cooley's erythroblastic anaemia. Indian Med. Gaz., 74: 660-664.

Narayanappa A. 1963. Thalassaemia major in a Shimoga family. J. Indian Med. Assoc., 41: 315-316.

Negi R.S. 1962. The incidence of sickle-cell trait in two Bastar tribes. I. Man, 62: 84-86.

Negi R.S. 1963. The incidence of sickle-cell trait in Bastar. II. Man, 63: 19-23.

Negi R.S. 1964. The incidence of sickle-cell trait in Bastar. III. Man, 64: 171-174.

Nijenhuis L.E. 1963. Blood group frequencies and haemoglobin types in Tibetans and Nepalese. Vox. Sang., 8: 622-626.

Pande S.R., Bhattacharya S.R., Gupta S.C., Mehrotra T.N. 1970. Abnormal haemoglobins in Indian Armed Forces personnel. Indian J. Med. Res., 58: 1017-1024.

Pande S.R., Mehrotra V.G., Mehrotra T.N. 1972. Study of abnormal haemoglobins in professional blood donors. J. Indian Med. Assoc., 58: 383-384.

Parekh J.G., Sharma R.S., Shah K.M. 1963. Hereditary persistence of foetal haemoglobin in combination with thalassaemia in the Indian families. J. Assoc. Physicians India, 11: 975-981.

Parikh N.P., Baxi A.J., Jhala H.T. 1969*a*. Blood groups, abnormal haemoglobins and other genetical characters in three Gujarati-speaking groups. Hum. Hered., 19: 486-498.

Parikh N.P., Baxi A.J., Jhala H.T., Kulkarni K.V. 1969*b*. Blood groups and other geneitcal characters in Mahars - a socially low caste from Maharashtra. Indian J. Med. Res., 57: 1467-1474.

Patel N.D., Bhende Y.M. 1939. Erythroblastic anaemia with kyphosis and cirrhosis of liver. Indian J. Pediatr., 6: 217-222.

Pirzada M.A., Kapoor P.N. 1950. Cooley's anaemia Indian Med. Gaz., 86: 150-152.

Praharaj K.C., Mohanta K.D., Kar R.S., Swain U., Nanda B.K. 1969. Haemoglobinopathy in Orissa. Indian Pediatr., 6: 533-537.

Punt K., Goel J.V. 1957. Thalassaemia-haemoglobin E disease in two Indo-European boys. Acta. Haematol. (Basel), 17: 305-314.

Rao U., Chouhan D.M., Saraiya U., Sharma R.S., Parekh J.G. 1969. Sickle cell thalassaemia (microdrepanocytic disease) and pregnancy. A case report. J. Obstet. Gynaecol. India, 19: 571-577.

Raper A.B. 1957. Unusual haemoglobin variant in a Gujerati Indian. Br. Med. J., 1: 1285-1286.

Reddy D.G., Baruah I.K. 1966. Sickle cell anaemia: a study of three cases from autopsy material and one clinical case. J. Indian Med. Assoc., 46: 163-165.

Reddy D.J., Rao K.S., Rao P.S. 1966. Sickle cell anaemia in Visakhapatnam. J. Indian Med. Assoc., 46: 69-72.

Roy D.N., Roy Chaudhuri S.K. 1967. Sickle cell trait in the tribal population of Madhya Pradesh and Orissa. J. Indian Med. Assoc., 49: 107-112.

Saha N., Banerjee B. 1965. Incidence of abnormal haemoglobins in Punjab. Calcutta Med. J., 62: 82-86.

Saha N. 1970. Prevalence of abnormal haemoglobins in pulmonary tuberculosis in three different ethnic groups. J. Med. Genet., 7: 44-46.

Saha N., Banerjee B. 1971. Incidence of abnormal haemoglobins in different ethnic groups of Indians. Humangenetik, 11: 300-303.

Salgia K.M., Gupta J.C., Arora M.M., Bhandari N.R., Jain A.C.S. 1965. Sickle cell anaemia. J. Indian Med. Assoc., 45: 271-273.

Sanghvi L.D., Sukumaran P.K., Lehmann H. 1958. Haemoglobin J trait in two Indian women

https://doi.org/10.1017/S1120962300017650 Published online by Cambridge University Press

associated with thalassaemia in one. Br. Med. J., 2: 828-830.

Sanghvi L.D. 1962. Haemoglobin Survey in Maharashtra. Lecture, Department of Human Genetics, University of Michigan.

Sarkar U.S., Ghosal S.P., Chaudhuri J.N. 1959. Thalassaemia haemoglobin-E disease. Indian J. Pediatr., 26: 361-370.

Sayed B.A., Amin S.P. 1966. A survey of sickle-cell trait in Bhil tribe in Baroda district with blood group data. J.J.J. Hosp. Grant. Med. Coll., 11: 169-171.

Sen D.K. 1960. Blood groups and haemoglobin variants in some upper castes of Bengal. J.R. Anthropol. Inst. (Gr. Br.), 90: 161-174.

Sharma J.C. 1968. Convergent evolution in the tribes of Bastar. Am. J. Phys. Anthropol., 28: 113-118.

Sharma R.S., Parekh J.G., Shah K.M. 1963. Haemoglobinopathies in Western India. J. Assoc. Physicians India, 11: 969-973.

Shukla R.N., Parande A.S. 1956. Occurrence of sickle cell trait in Nagpur. Indian J. Med. Sci., 10: 892-895.

Shukla R.N., Solanki B.R., Parande A.S. 1958. Sickle cell disease in India. Blood, 13: 552-558.

Shukla R.N., Solanki B.R. 1958. Sickle cell trait in Central India. Lancet, 1: 297-298.

Siddoo J.K., Siddoo S.K., Chase W.H., Morgan-Dean L., Perry W.H. 1956. Thalassaemia in Sikh. Blood, 11: 197-210.

Srinivasan T., Rao V.R.M., Sitamahalaksmi G. 1966. Thalassaemia major in a family from Guntur district. J. Indian Med. Assoc., 47: 181-183.

Stern M.A., Kynoch P.A.M., Lehmann H. 1968. β-thalassaemia, glucose-6-phosphate dehydrogenase deficiency and haemoglobin D Punjab in Pathans. Lancet, 1: 1284-1285.

Subhedar B.J., Bhargava H.S., Choubey B.S., Solanki B.R. 1961. Haemoglobin-J in a Harijan family. J. Assoc. Physicians India, 9: 501-505.

Subbarao R.V., Jayam A.V., Sukumaran P.K. 1968. Sickle cell thalassaemia. J. Postgrad. Med., 14: 89-94.

Sukumaran P.K., Sanghvi L.D., Vyas G.N. 1956. Sickle cell trait in some tribes of Western India. Curr. Sci., 25: 290-291.

Sukumaran P.K., Sanghvi L.D., Ager J.A.M., Lehmann H. 1959. Haemoglobin L in Bombay: findings of three Gujerati-speaking Lohana families Acta Genet. (Basel), 9: 202-206.

Sukumaran P.K., Sanghvi L.D., Nazreth F.A. 1960. Haemoglobin D-thalassaemia. A report of two families. Acta Haematol. (Basel), 23: 309-319.

Sukumaran P.K., Randelia H.P., Sanghvi L.D., Merchant S.M. 1961. Thalassaemia syndrome in Bombay. J. Assoc. Physicians India, 9: 477-488.

Sukumaran P.K., Wiltshire B.G., Lehmann H. 1971. A new haemoglobin Q$^{\alpha 64}$ (aspartic acid→histidine) observed in two Sindhi families. 2nd Meeting of Asia Pacific Div. of Int. Soc. Haematol. (Melbourne).

Sukumaran P.K., Merchant S., Desai M.P., Wiltshire B.G., Lehmann H. (1972). Haemoglobin Q India [α^{64} (E_{13}) aspartic acid→histidine] associated with β-thalassaemia observed in three Sindhi families. J. Med. Genet., 9: 436-442.

Sur A.M., Chakravarty A., Rawat M.S. 1968. Sickle cell haemoglobin in children. Indian Pediatr., 5: 308-314.

Swarup S., Ghosh S.K., Kundu A.B., Chatterjea J.B. 1959. Abnormal haemoglobins in Mysore. J. Indian Med. Assoc., 33: 209-210.

Swarup S., Ghosh S.K., Chatterjea J.B. 1963. A report of fast-moving haemoglobins in Bengalees. Bull. Calcutta Sch. Trop. Med., 11: 137-138.

Swarup S., Banerji P.G., Ghosh S.K., Chatterjea J.B. 1965. Haemoglobin Bart's in Bengalee blood. Bull. Calcutta Sch. Trop. Med., 13: 47-48.

Swarup S., Ghosh S.K., Chatterjea J.B. 1966*a*. Haemoglobin E and K and thalassaemia in an Indian family with evidence of interaction between haemoglobin E and thalassaemia. J. Indian Med. Assoc., 46: 587-589.

Swarup S., Ghosh S.K., Chatterjea J.B. 1966*b*. Haemoglobin J in a Bengalee family with evidence of interaction between haemoglobin J and thalassaemia. J. Indian Med. Assoc., 46: 590-594.

Swarup S., Ghosh S.K., Chatterjea J.B. 1966*c*. Paper presented to the 7th Annual Conference of the Indian Society of Haematology. Quoted by Chatterjea 1966.

Tiagi G.K., Halder P.K., Laha P.N. 1954. Cooley's anaemia in India. Indian J. Med. Sci., 8: 744-749.

Trincão C., De Almeida F.L.T., Martins De M.J., Surlear L. 1963. Abnormal haemoglobins in Portuguese India. (Goa and Diu territories). Proc. 9th Congr. Europ. Soc. Haematol. (Lisbon, 1963). S. Karger, New York, pp. 474-476.

Udani P.M., Parekh J.G., Sharma R.S. 1961. Proc. Annual Conference of the Indian Society of Haematol., Madras.

Udani P.M., Parekh J.G., Sharma R.S. 1963. Haemoglobin "E" thalassaemia. J.J.J. Group Hosp. & Grant. Med. Coll., Bombay, 8: 259-263.

https://doi.org/10.1017/S1120962300017650 Published online by Cambridge University Press

Undevia J.V. 1969. Population Genetics of the Parsis. Thesis submitted to the University of Bombay for Ph.D.

Vella F., Field T. E. 1958. Abnormal haemoglobins in Maly and Nepalese Gurkha soldiers. Med. E Malaya, 13:153-158.

Vella F. 1962*a*. Abnormal haemoglobins, thalassaemia and erythrocyte glucose-6-phosphate dehydrogenase deficiency in Singapore and Malaya. Oceania, 32: 219-225.

Vella F. 1962*b*. La microcitemia e il morbo di Cooley a Malta, Singapore, e Khartoum. Istituto Italiano di Medicina Sociale (Roma), 1:158-173.

Vyas G.N., Bhatia H.M., Sukumaran P.K., Balakrishnan V., Sanghvi L.D. 1962. Study of bllod groups and abnormal haemoglobins and other genetical characters in some tribes of Gujerat. Am. J. Phys. Anthropol., 20: 255-265.

Weatherall D.J., Vella F. 1960. Thalassaemia in a Gurkha family. Br. Med. J., 1: 1711-1713.

Wickremasinghe R.L., Ikin E.W., Mourant A.E., Lehmann H. 1963*a*. The blood groups and haemoglobins of the Veddahs of Ceylon. J. R. Anthropol. Inst. (Gr. Br.), 93: 117-125.

Wickremasinghe R.L., Ikin E.W., Mourant A.E., Lehmann H. 1963*b*. Blood groups and haemoglobin types of Ceylonese. Spolia Zeylania (Bull. Nat. Mus., Ceylon), 30: 149-154.

World Health Organization 1972. Treatment of haemoglobinopathies and allied disorders. Techn. Rep. Ser. No. 509, pp. 15.

ADDED IN PROOF. Sinha et al. (1973) investigated 2075 subjects in the Indian Armed Forces personnel, coming from different states of India, and reported the presence of Hbs AD in 13, D-thalassaemia in 1, AE in 3, and EE in 3 individuals. Schroeder et al. (1973) reported the presence of hereditary persistence of foetal haemoglobin in the heterozygous state γ glycine (136) and γ alanine (136) in 6 persons from four Indian families. In 3 of them it was associated with β-thalassaemia. Further, Sukumaran et al. (1972) reported homozygous state of hereditary persistence of foetal haemoglobin γ glycine (136) in two Indian families.

Schroeder W.A., Huisman T.H.J., Sukumaran P.K. 1973. A second type of hereditary persistence of foetal haemoglobin in India. Br. J. Haematol., 25: 130-135.

Sinha R., Mehrotra T.N., Gupta S.C., Kapoor K.K. 1973. Abnormal haemoglobins in the Indian Armed Forces personnel. Indian J. Med. Res., 61: 1299-1307.

Sukumaran P.K., Huisman T.H.J., Schroeder W.A., McCrudy P.R., Freehafer J.T., Bouver N., Shelton J.R., Shelton J.B., Appel G. 1972. A homozygote for the HbGγ type of foetal haemoglobin in India: a study of two Indian and four Negro families. Br. J. Haematol., 23: 403-417.

RIASSUNTO

Viene presentata una aggiornata rassegna bibliografica sulla distribuzione delle emoglobinopatie nel subcontinente indiano. In India sono state finora descritte le emoglobine S, D, E, J, K, L, M, Q, la β-talassemia major, la β-talassemia minor, la α-talassemia minor, l'emoglobina H, l'emoglobina Lepore e la persistenza dell'emoglobina fetale. È anche stata riportata la β-talassemia in combinazione con le emoglobine S, E, D, J, K e Q. L'emoglobina S è risultata più frequente nelle popolazioni tribali di varie regioni dell'India, mentre l'emoglobina D prevale nei Sikh, Pathani e Gujrati. L'emoglobina E ha una frequenza elevata nelle popolazioni di Assam e Bengala e nei Veddah di Ceylon. La β-talassemia major è diffusa in diverse popolazioni. Sulla distribuzione della β-talassemia minor e delle α-talassemie, vi è scarsezza di dati.

RÉSUMÉ

Une revue bibliographique est présentée concernant la distribution des hémoglobinopathies dans le subcontinent indien. Jusqu'à présent y ont été décrites les hémoglobines S, D, E, J, K, L, M, Q, la β-thalassémie major, la β-thalassémie minor, l'α-thalassémie minor, les hémoglobines H et Lepore, ainsi que la persistence de l'hémoglobine fétale. La β-thalassémie en combinaison avec les hémoglobines S, E, D, J, K et Q a aussi été rapportée. L'hémoglobine S est plus fréquente parmi les populations tribales de différentes régions de l'Inde, alors que l'hémoglobine D est plus fréquente parmi les Sikhs, Pathans et Gujratis. L'hémoglobine E est très fréquente parmi les populations de l'Assam, du Bengale et les Veddahs de Ceylon. La β-thalassémie major est répandue dans plusieurs populations, alors qu'il-y-a peu de données sur la distribution de la β-thalassémie minor et des α-thalassémies.

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ZUSAMMENFASSUNG

Übersicht über die neuesten Arbeiten, die sich mit der Distribution der Hämoglobinopathien auf dem indischen Subkontinent befassen. Bisher wurden in Indien folgende Hämoglobine beschrieben: S, D, E, J, K, L, M, Q, β-Thalassämie major, β-Thalassämie minor, α-Thalassämie minor, Hb H, Hb Lepore und das persistente fötale Hb. Es wurde auch über β-Thalassämie in Verbindung mit den Hämoglobinen S, E, D, J, K, Q berichtet. Bei den noch in Volksstämmen lebenden Bevölkerungen der verschiedenen Regionen Indiens war Hb S häufiger, während Hb D bei den Sikh, Pathani und Gujrati vorwiegen. Hb E findet sich recht häufig bei den Populationen von Assam, von Bengala und bei den Veddah auf Ceylon. Die β-Thalassämia major ist bei verschiedenen Bevölkerungen verbreitet. Über die Diffusion der β-Thalassämia minor und der α-Thalassämien bestehen noch zu geringe Angaben.

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