

## Dermal ulcers and hypertension in salt workers

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**In the process of salt manufacture, brine rich in salt is filled in broad pans exposed to direct sunlight. Brine workers keep their feet in the brine while working in these pans. They frequently have traumatic ulcers on their feet and hands. The aim of the present communication was to find out if prevalence of hypertension and blood pressure in brine workers was affected by the presence of ulcers on their limbs. In our cross-sectional observational study, all workers ( $n = 218$ ) were clinically examined. Blood pressure was measured. Systolic and diastolic blood pressure of brine workers having ulcers on their limbs was compared with those not having the ulcers. In brine workers having ulcers, prevalence of hypertension was 15.6%, while it was 4.3% in those not having ulcer. Prevalence of hypertension was significantly higher in the group of brine workers with ulcers ( $P = 0.036$ ) and this may be due to absorption of salt through the damaged skin.**

SALT manufacturing is an important industry in Rajasthan, engaging more than 20,000 workers<sup>1</sup>. In the process of salt manufacture, highly concentrated brine (groundwater rich in salt, used for salt manufacture) is filled in broad pans made on the surface of land, exposed to direct sunlight. Water evaporates from this brine and sodium chloride is crystallized at the bottom of the pan. In these pans, brine workers sweep crystals of salt using broad wooden spades and make heaps of salt near the edge of the pan. Their feet and lower portion of their legs remain submerged in brine for 4 to 8 h per day. Often their upper limbs are also wet with brine or are covered with fine salt particles. They frequently sustain minor occupational injuries on their feet and hands resulting in the formation of ulcers, which heal slowly. There is a possibility of absorption of significant amount of salt through such ulcers, which in turn may affect their blood pressure. High salt content in diet is known to increase blood pressure as well as prevalence of hypertension in salt-sensitive subjects<sup>2</sup>. The aim of the present communication was to find out if prevalence of hypertension and blood pressure of brine workers was affected by the presence of ulcers on their limbs.

This was a cross-sectional observational study. In Rajasthan, occupational health check-up camps were held at three salt-manufacturing sites, under a project on

'Prevention and Control of Occupational Health Hazards Among the Salt Workers', sponsored by the Ministry of Health, Government of India. This project was approved by the Scientific Advisory Committee of National Institute of Occupational Health, Ahmedabad, India. The camps were organized at Sambhar, Nawa and Phalodi in collaboration with owners of salt-manufacturing units and Department of Salt, Government of India. Each camp was of five days duration. All the workers from nearby salt-manufacturing units were invited for their free health examination. The workers who were absent on the dates of the health camp were excluded from the study. All workers whose nature of job involved working in brine pans, were classified as brine workers. Brine workers who were also engaged in other processes related to salt like loading, weighing, transporting, milling or packing of salt were excluded from the analysis.

Eight hundred ninety-one salt workers attended the camps, out of which 218 who fulfilled the above inclusion criteria were taken as brine workers for the present analysis. Their age in completed years, sex, detailed occupational history, including exact nature of job and duration of working in salt industry were recorded in performa specially designed for occupational health examination.

After obtaining their informed consent, clinical examination including detailed dermatological examination was carried out by one of the authors, who did not measure blood pressure. Blood pressure of all brine workers was measured in supine position after rest of five minutes. Blood pressure was measured in the right arm using digital blood pressure equipment (Omron T-4). The cuff size was 25 cm  $\times$  13 cm. Three readings were taken by trained field investigators under the supervision of the first author. The first two readings were to familiarize the subjects with the process and the third reading was taken for analysis. The field investigators were trained to measure blood pressure for fifteen days by the authors. Body weight and height were measured by another field inves-

**Table 1.** Characteristics of study subjects

Characteristics	Brine workers having ulcer/s on limb/s ( $n = 32$ )	Brine workers not having any ulcer on limbs ( $n = 186$ )	<i>P</i> -value
Age (years)	29.72 $\pm$ 9.78	31.04 $\pm$ 8.87	0.10*
Gender M/F (%)	93.7/6.3	84.4/15.6	0.16**
Literacy (%)	37.5	33.3	0.65**
Income (Rs per annum)	23740 $\pm$ 10076	23456 $\pm$ 14615	0.10*
Smokers (%)	56.3	46.8	0.32**
Alcohol users (%)	9.4	8.1	0.80**
BMI kg/m <sup>2</sup>	18.69 $\pm$ 2.06	18.81 $\pm$ 2.14	0.10*
Duration of salt work (years)	10.63 $\pm$ 9.17	10.91 $\pm$ 7.03	0.10*
Vegetarians (%)	65.6	64.5	0.90**

\*Student's *t* test was applied.

\*\*Chi-square test was applied.

**Table 2.** Prevalence of hypertension (HT) according to age

Age in years	Brine workers having ulcers		Brine workers not having ulcers	
	No. examined	Prevalence of HT (%)	No. examined	Prevalence of HT (%)
15–19	4	0.0	17	0.0
20–29	13	15.4	62	4.8
30–39	5	20.0	68	2.9
40–49	9	22.2	32	3.1
50+	1	0.0	7	28.6
Total	32	15.6*	186	4.3*

\* $\chi^2 = 4.39$ ,  $P = 0.036$ .

tigator trained for the purpose. Height was measured in centimetres, using anthropometric rod, while the subject stood erect on a flat platform. Body mass index (BMI) was calculated as [(weight in kg/height in metres)<sup>2</sup>]. Systolic and diastolic blood pressure of brine workers having ulcers on their limbs was compared with those not having ulcers. Hypertension was defined as systolic blood pressure more than 139 and/or diastolic blood pressure 90 or  $t$  test and chi-square test were used to study statistical significance of the differences.

Out of 218 brine workers, 32 (14.7%) had ulcer/s on their hands, feet or lower portion of their legs. The characteristics of the study subjects are depicted in Table 1 and were comparable in brine workers with ulcers and those without ulcers. Both groups did not have significant difference in prevalence of smoking, alcohol use, age, literacy, income, duration of working in salt industry and BMI.

Prevalence of hypertension was significantly higher in those with ulcer (15.6%) than in those not having ulcer/s (4.3%) ( $\chi^2 = 4.39$ ,  $P = 0.036$ ; odds ratio = 4.12). All hypertensive workers with ulcers had systolic hypertension, but diastolic blood pressure in all of them was less than 90 mm of mercury.

Mean systolic blood pressure in those having ulcers was  $121.84 \pm 12.42$  mm of mercury and in those not having ulcers was  $117.73 \pm 12.13$  mm of mercury. The difference was statistically not significant ( $t = 1.77$ ,  $df = 216$ ,  $P = 0.08$ ). Mean diastolic blood pressure in those having ulcers was  $67.44 \pm 10.65$  mm of mercury and in those not having ulcers was  $69.11 \pm 8.82$  mm of mercury; the difference was not statistically significant ( $t = 0.96$ ,  $df = 216$ ,  $P > 0.10$ ).

In the present study, overall prevalence of hypertension among brine workers was 6.0%, which was higher in those having ulcers (15.6%; Table 2). Higher prevalence of hypertension was consistently observed in all age groups in workers having ulcers, while among workers not having ulcers, prevalence of hypertension was high only in those above 50 years of age. However, hypertension has not been found to be an occupational health problem of rock salt-mine<sup>3</sup> and harbour workers<sup>4</sup>. Overall prevalence of hypertension in rural population of northwest India<sup>5–8</sup> has been found to be 3.4–7.2%.

In India, salt is mainly manufactured from the sea shore and subsoil brine. Rajasthan is the second largest producer of salt from subsoil brine in India. Salt workers are low-paid and do not use gum boots or other safety measures. As a result, their skin is often damaged by salt crystals and the spade used for sweeping them. Brine workers work in pans containing concentrated brine and their feet and lower legs remain submerged in brine. The present study depicts higher prevalence of hypertension among brine workers having ulcers on their limbs. A probable explanation of this observation may be the possibility of absorption of salt through the skin. When salt concentration in fluid surrounding the skin is high, osmotic pressure and ion-exchange make a significant contribution to flux enhancement by diffusion potential<sup>9</sup>. Presence of ulcers on the skin is likely to increase salt absorption as percutaneous absorption of various substances, including salt is known to be higher through damaged skin<sup>10–12</sup>. This might cause elevation of blood pressure in brine workers having damaged skin, though this hypothesis needs to be confirmed. Zhou *et al.*<sup>2</sup> studied the relationship of dietary patterns with blood pressure in ten population groups and found mean daily intake of sodium showed significant positive association with both systolic and diastolic blood pressure in all groups, except the fishermen. This observation supports our hypothesis as percutaneous absorption of varying quantity of salt among fishermen may be the cause for lack of association between dietary salt intake and blood pressure in them. The limitation of the study is that the workers were not followed and it could not be known whether hypertension disappears after healing of ulcers or discontinuation of work for few days. Furthermore, biochemical investigation of serum and urinary electrolytes could not be done due to lack of facility. Frequent damage of skin and subsequent healing may be an important risk factor for development of hypertension in salt workers. Further studies are needed to elucidate our findings.

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ACKNOWLEDGEMENTS. Ministry of Health and Family Welfare, Govt. of India had financed the project on salt workers working in desert areas of Gujarat and western Rajasthan. We thank the Salt Commissioner, Government of India and his team for cooperation.

Received 12 March 2004; revised accepted 14 June 2004

## Is River Ghaggar, Saraswati? Geochemical constraints

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**The identity of the river along which the famous Harappan Civilization developed and the causes of the demise of this culture are topics of considerable debate. Many of the Harappan sites are located along the ephemeral Ghaggar river within the Thar Desert**

**in the northwestern India and adjacent Pakistan. The Ghaggar was also thought to be the mythical river Saraswati, which was described as glacial-fed river. Sr and Nd isotopic composition of the Ghaggar alluvium as well as Thar Desert sediments suggests a Sub-Himalayan sediment source, with no contribution from the glaciated regions. The development of extensive Harappan Civilization all along the Ghaggar suggests a catchment with high monsoon rainfall. It is likely that with the changes in the monsoon scenario after 3500 BC could have gradually dried up the Ghaggar river and resulted in the migration and/or extinction of the Harappan Civilization on this river.**

THE largest and the oldest urban civilization of the world was the Indus Valley (Harappan) Civilization of north-west India and Pakistan<sup>1</sup>. Almost two-thirds of nearly 1500 archaeological sites of this civilization occur on the dried banks of the Ghaggar river<sup>2</sup> (Figure 1). The River Ghaggar originating in the Sub-Himalayas flows through the northern part of the Thar today as an ephemeral river mainly during the SW monsoon season and disappears in the desert. However, the river seems to have played a key role in the development of the Harappans<sup>2,3</sup>. The Ghaggar river has been identified with the mighty glacial-fed river Saraswati<sup>4–6</sup>, which is described in the oldest religious document written in Sanskrit, the *Rig-Veda* (1500 BC)<sup>7,8</sup>. Based on geomorphological studies and identification of clasts in the river channels of outer Himalayas, it has been suggested that the palaeo-Ghaggar (alias Saraswati) had its catchment in the glaciated Higher Himalayas<sup>9,10</sup>. Another prevalent hypothesis is that the ancestral channels of Yamuna and Satluj once fed the Saraswati<sup>9,11</sup>. The antecedent Yamuna and Satluj rivers originate from the glaciated Higher and Tibetan Himalayas respectively, and limit the expansion of the Thar Desert in the east and north. If water availability is the key climate determinant for life<sup>12</sup> and the region was already experiencing aridity<sup>13</sup>, the palaeo-Ghaggar must have been perennial for the Harappans to flourish. To identify the source (glaciated or non-glaciated terrains) and the nature (perennial or ephemeral) of the palaeo-Ghaggar and, therefore, to understand the likely cause of the social collapse of the Harappans, we have studied Sr and Nd isotopic characteristics of the sediments deposited by desert-forming processes and by the River Ghaggar in the Thar Desert region of northwestern India and compared these with the values of other Himalayan rivers in the region and with those of various Himalayan lithotectonic units.

Recycled sediments formed due to cannibalistic processes of erosion and subsequent deposition pose difficulties for the identification of their sources. However, in the Himalayan orogen, Sr and Nd isotopes have been successfully used to identify different lithostratigraphic zones<sup>14</sup> and to locate the source areas of sediments of the Tertiary foreland basins<sup>15,16</sup>, Bengal fan<sup>17</sup> and those of the present-day Himalayan rivers<sup>18</sup>. Identification of sediment

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