RISK OF HIGH BLOOD PRESSURE IN SALT WORKERS WORKING NEAR SALT MILLING PLANTS

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Abstract

Background: Workers working close to salt milling plants may inhale salt particles floating in air leading to rise in plasma sodium which in turn may increase the blood pressure and the risk of hypertension.

Methods: To test above hypothesis, occupational Health Check-up camps were organised near salt manufacturing units and all workers were invited for their free health examination. The workers who worked with dry salt in vicinity of salt milling plants were defined as non-brine workers, while those working in brine pans far away from milling plants were defined as brine workers. Their clinical examination was carried out and Blood pressure was measured. In all 474 non-brine workers and 284 brine workers were studied.

Results: Mean systolic blood pressure of non-brine workers (122.1±13.3 mm Hg) was significantly higher than that of brine workers (118.8±12.8 mm Hg, p=0.00086). Mean diastolic blood pressure of non-brine workers (71.5 ± 10.4 mm Hg) was significantly higher than that of brine workers (69.7±9.4 mm Hg, p= 0.01497). The prevalence of hypertension was significantly higher in non-brine workers (12.2%) than in brine workers (7.0%, p=0.023). Nineteen salt workers were monitored while they used face masks and spectacles for six days. Systolic as well as diastolic blood pressure of these workers began declining on third day, continued to decline on forth day but remained stationary thereafter up to sixth day.

Conclusion: Concentration of salt particles in breathing zone of these workers was 375.84 mg/m^3 air, which may be cause of high BP of the exposed workers.

Introduction:

There is an abundance of scientific evidence demonstrating a direct relation between salt intake and blood pressure (BP) [1]. Many animal studies [2], large population based studies [1,3-6], epidemiological studies [7-9], meta-analyses of clinical trials [10-13] and randomized controlled trials [14-15] have shown that BP is directly related to salt intake. Occupations of people also have varying impact on their BP [16-20]. Salt workers involved in the process of manufacture, milling and packing of salt are exposed to salt in their environment. Since most salt milling plants in India are not well enclosed, salt particles float in air in their vicinity. The workers working at such sites may therefore inhale considerable amount of salt during working hours. These inhaled salt particles may be absorbed from airway surface epithelium [21- 25] or from lungs [26] and fine particles are also able to translocate from the lungs into the systemic circulation [27]. Inhaled salt particles may be carried may continuous upward mucocilliary current on airway surface to throat from where these can be swallowed. This is likely to increase the plasma sodium level, which in turn may increase the BP [28] and may increase the risk of hypertension in the exposed workers, though this problem may be completely preventable. This hypothesis was tested through a cross sectional and an experimental study involving salt workers; the results are presented and discussed in present paper.

Methods

A cross-sectional study was conducted among salt workers of Sambhar, Nawa and Rajas salt manufacturing sites of Rajasthan which are at about 150 km. from Jaipur, the capital of Rajasthan. Occupational Health Check-up camps were held at these three salt manufacturing sites, under project on Prevention and control of

Occupational Health Hazards among the Salt Workers, sponsored by Ministry of Health, Government of India. This project was approved by 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 5 days duration. All the workers of nearby salt manufacturing units were invited for their free health examination. The workers who were absent on the dates of the health camp were not included in the study.

The aim of the study was explained to the subjects. 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, their clinical examination was carried out by one of the authors, who did not measure blood pressure. Blood pressure of all workers was measured in supine position after a rest for five minutes. Blood pressure was measured in right arm using digital blood pressure equipment (Omron T-4). The cuff size was 25 cm X 13 cm. Three readings were taken by the trained field investigators under supervision of another author. First two readings were to familiarize the subjects with the process and the third reading was recorded for analysis. The field investigators were trained for measuring blood pressure for fifteen days by the authors. Body weight and height were measured by another field investigator, trained for the purpose. Height was measured in centimeters, using anthropometric rod, while subject stood erect on a flat platform.

Eight hundred ninety one salt workers attended the camps but three blood pressure measurements were taken in 875 workers. The workers who were involved in crushing, grinding, milling, packing and loading of salt and did not work with brine were defined as non-brine workers. These workers worked in vicinity of salt milling plants. Workers who worked in brine pans for crystal reshuffling and raw salt heaping were defined as brine workers, their site of work was far away from salt milling plants. The workers who worked as non-brine workers for some time and also worked as brine workers on some other days were excluded from analysis. Workers who were involved in only administrative and other related activities were also excluded from the analysis. Data pertaining to 474 non-brine workers and 284 brine workers were included in the final analysis.

Hypertension was defined as systolic blood pressure more than 139 and/or diastolic blood pressure 90 or above. Body mass index was calculated as [Weight in Kg/(Height in meters)^2]. Systolic and diastolic blood pressure was compared in the brine workers and non-brine workers. Student 't' test and Chi square test were used to study statistical significance of the differences.

Since mean systolic BP, mean diastolic BP and prevalence of hypertension were found to be significantly higher in non-brine workers as compared to brine workers, an intervention study was carried out to test the hypothesis that exposure of non-brine workers to salt particles floating in environment may contribute to rise in their blood pressure. For this purpose thirty-three non-brine workers, working at or close to salt milling plant, who volunteered to participate in the study were registered. They were explained about the hypothesis and were provided face masks and the spectacles with plane glasses. The masks were dust guards made of poly vinyl chloride containing a disposable filter cartridge of nitrocellulose. In an earlier study

carried out by us, it could filter 82.8% dust particles of size 10 microns or less. The workers were trained and were motivated to use them properly while working. They were observed and followed for six consecutive days, during this period their resting blood pressure was measured in supine position in morning before starting work. Only nineteen of them regularly attended the worksite and used face mask and eyeglasses for all six consecutive days, others were present on some days while absent on other days. They were requested to provide their urine samples before starting intervention study and after using intervention for more than 3 days. Urine samples were collected twice a day, once in morning before starting work and then in the evening after completion of the working hours. Only eight subjects of 33 workers, provided both (morning and evening) urine samples before intervention and six workers (not the same) provided both urine samples after intervention. Urine samples were analysed for sodium and potassium levels using electrolyte analyzer.

The concentration of salt particles in air in environment of working site of worker was measured by using respirable dust sampler (Environtech).

Results

Out of 758 salt workers studied, 474 (62.5%) workers were non-brine workers while 284 (37.5%) were brine workers. The characteristics of the study subjects are depicted in Table 1. These were comparable in brine and non-brine workers. Mean age of male brine workers was 31.8 ± 9.8 years while male non-brine workers were comparatively little younger (mean age 29.2 ±10.0 years.). Mean age of female brine workers (35.1±10.9 years) was not significantly different from that of female non-brine workers (36.5 ±10.5 years). All workers were 15 years or above in age. Both groups did not have significant difference in prevalence of smoking, alcohol use,

literacy, income, diet habits, and BMI. However mean duration of working in salt industry was lower in non-brine workers than brine workers.

Mean systolic blood pressure of non-brine workers (122.1 ± 13.3 mmHg) was significantly higher than that of brine workers (118.8 ± 12.8 mm Hg)(p=0.00086). Z test as well as Student 't' test (Two tail) showed this difference highly significant in both sexes separately (Table 2). Mean diastolic blood pressure of non-brine workers (71.5 ± 10.4 mm Hg) was significantly higher than that of brine workers (69.7 ± 9.4 mm Hg) (p= 0.01497). This was also consistently higher in both sexes.

Over all prevalence of hypertension in salt workers was 10.3%. It was significantly higher in non-brine workers (12.2%) than in brine workers (7.0%) (p=0.023). The prevalence of hypertension was consistently higher in non-brine workers than brine workers in different groups according to age, sex, literacy, income, Body-mass index, duration of working in salt industry, smoking, alcohol use, tobacco chewing and diet (Table 3).

Results of experimental intervention: Table 4 shows mean number of working hours, mean number of hours for which masks and glasses were used and mean morning blood pressure, of nineteen workers who attended the worksite and used face mask and eyeglasses for all six days of intervention. Morning blood pressure was taken before starting of the shift. The systolic as well as diastolic blood pressure of these workers began declining on the third day, continued to decline on forth day but remained stationary thereafter (Figure 1). Table 5 shows that difference in blood pressure of day 1 and day 2 was not significant but that between day 2 and day 3 as well as between day 3 and day 4 was significant and again decline thereafter was

insignificant. Mean urinary sodium in morning samples before intervention was 265.7±250.8 mmol/day and was 184.6±46.3 mmol/day three days after intervention. The decline was not statistically significant. Mean urinary sodium in evening samples before intervention was 310.8±304.2 mmol/day and was 180.5±41.2 mmol/day three days after intervention. The decline was not statistically significant. Mean concentration of salt particles of size less than 10 microns (PM 10) was 15.28 mg/m^3 and that of larger particles was 360.56 mg/m^3 air in the breathing zone of these workers during these six days.

Discussion

In present study, systolic as well as diastolic BP and prevalence of hypertension were found to be higher in non-brine salt workers who were occupationally exposed to sodium chloride particles in air of breathing zone. This is a new observation not reported earlier, though it is in line with the hypothesis that after being inhaled during breathing, salt may be absorbed from respiratory tract [21-25] or mucocilliary current may transport it to pharynx from where it is swallowed and can then be absorbed from gastrointestinal tract. Consequent increase in plasma sodium may be responsible for increases in the BP [28]. Differences in urinary sodium, an indicator of sodium intake and plasma sodium are associated with BP differences of clinical and public health relevance [29]. The exact mechanisms whereby raised plasma sodium increases the BP are not clear. Existing concepts focus on the tendency for an increase in extracellular fluid volume (ECV), but raised plasma sodium increases a transfer of fluid from the intracellular to the extracellular space, and stimulates the thirst center. Accordingly, the rise in plasma sodium is responsible for the tendency for an increase in ECV. Although the change in ECV

may have a pressure effect, the associated rise in plasma sodium itself may also cause the BP to rise [28]. Systolic and diastolic BP and prevalence of hypertension of the non-brine (exposed) workers were compared with the brine salt workers who were not exposed to salt particles in air. BP is affected by multiple factors including age, nature of job, socioeconomic status, living standard, nutritional status, smoking habits and alcohol consumption. Both groups of studied workers did not differ on these parameters (Table 1). Mean age and mean duration of working in salt industry (exposure) were lower in non-brine workers as compared to brine workers, but these can be causes of lower BP rather than of higher BP in them. Since the observation was consistent in different groups according to various risk factors of hypertension (Table 3), the consistency further strengthens the observation. It can therefore safely be concluded that BP and prevalence of hypertension of non-brine workers were higher than brine workers.

To further confirm the hypothesis about probable mechanism involved, an experimental intervention was carried out. The decline in BP on using face masks and spectacles while working again strengthens the hypothesis. The urinary sodium levels also declined after use of masks and glasses for three days, though the decline was not statistically significant probably because of smaller sample size. The limitation of the study is that serum sodium levels of the workers involved in intervention study could not be measured. Total concentration of salt particles in air was 375.84 mg/m^3. Considering average tidal volume of 450 ml/breath, respiratory rate of 12/min, average person could inhale 0.97 gm sodium chloride in a shift of eight hours. Average use of mask was for 52.9% of working hours, which could have prevented inhalation of about 0.5 gm of salt per day. The exact mechanism how this decline of

0.5 gm salt per day could significantly reduce the BP is not clear. The results of intervention study thus do not fully support the hypothesis that cause of higher BP and higher prevalence of hypertension in non-brine workers is inhalation of salt particles from the environment. Eye glasses were provided to protect their eyes from salt particles and the study design did not allow us to find out whether these contributed to lowering of BP, though the salt particle sticking on to conjunctiva may also pass along with tears through naso-lacrimal duct to respiratory tract. The psychological effect of using some intervention devices expected to reduce BP can also not be ruled out in this study. Further studies on salt workers are needed to elucidate our findings.

Competing interests: Authors declare that they don't have any competing interests.

Author's contributions: KR contributed in conception and design , acquisition of data, analysis and interpretation of data and drafting the paper ML contributed in acquisition of data, statistical analysis and interpretation of data and drafting the paper, R contributed in acquisition of data and drafting the paper, HN contributed in conception and design and critical evaluation of the data and drafting of the paper. All authors read and approved the final manuscript.

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Table 1. Characteristics of study subjects.

Characteristic	**Brine workers (n=284)**	**Non-brine workers (n=474)**	**p-value**
Age (Yeras)			
Males	31.8 ± 9.8 (N=238)	29.2 ± 10.0 (N=398)	p=0.001*
Females	35.1 ± 10.9 (N=46)	36.5 ± 10.5 (N=76)	p=0.487†
M + F	32.3 ± 10.0	30.4 ± 10.4	p=0.01*
Gender M/F (%)	83.8/16.2	84.0/16.0	p=0.97 ‡
Literacy (%)	35.2	43.5	p<0.03 ‡
Income (Rs. per anum)	17760.9 ± 12858.7	19684.5 ± 13761.4	p=0.057†
Smokers (%)	33.8	35.9	p=0.25 ‡
Alcohol users (%)	10.6	11.8	p=0.17 ‡
BMI Kg/m2	18.9±2.2	18.7 ± 2.5	p=0.28†
Vegetarians (%)	62.3	67.7	p=0.15 ‡
Duration of working in salt industry (Years)	11.4 ±7.2	8.7 ± 6.9	p<0.001*

*Difference significant; Student ‘t’ test was applied

† Difference Not significant; Student ‘t’ test was applied.

‡Difference Not significant; Chi Square test was applied.

Table 2. Mean systolic and diastolic blood pressure of brine workers and non-brine workers.

	Brine workers	Non-brine workers	p-value
Average systolic BP			
Males	119.9 ±11.7 (n=238)	122.8 ±12.4(n=398)	p=0.00348*
Females	113.2 ±16.6 (n=46)	118.3 ±16.5 (n=76)	p=0.09949
M+F	18.8 ± 12.8(n=284)	122.1 ± 13.3 (n=474)	p=0.00086*
Average diastolic BP			
Males	69.4 ±9.6 (n=238)	72.8 ±10.2(n=398)	p=0.08640
Females	71.1 ±7.8(n=46)	75.2 ±10.3 (n=76)	p=0.02330*
M+F	69.7 ± 9.4(n=284)	71.5 ± 10.4 (n=474)	p=0.01497*

* Difference significant; Z test and Student‘t’ test (two tail) were applied.

Table3: Prevalence of Hypertension in brine workers and non-brine workers according to various characteristics.

Characteristics	**Brine Workers**			**Non-brine Workers**		
	No.	**Hypertensive cases**		**No.**	**Hypertensive cases**	
		No.	**%**		**No.**	**%**
Age <40 years	208	11	5.3	368	33	9.0
40+ years	76	9	11.8	106	25	23.6
Sex Males	238	18	7.6	398	46	11.6
Females	46	2	4.3	76	12	15.8
Illiterate	184	16	8.7	268	38	14.2
Literate	100	4	4.0	206	20	9.7
Annual income Rs.<18000	179	10	5.6	256	33	12.9
>18000	105	10	9.5	218	25	11.5
BMI <18 Kg/m^2	109	3	2.8	185	18	9.7
18+ Kg/m^2	175	17	9.7	289	40	13.8
Duration of Work <10 Yrs	118	5	4.2	305	31	10.2
10+ Yrs	166	15	9.0	169	27	16.0
Smokers or ex-smokers	190	15	7.9	316	43	13.6
Non-smokers	94	5	5.3	158	15	9.5
Alcohol users or ex-users	259	17	6.6	430	55	12.8
Non-users	25	3	12.0	44	3	6.8
Tobacco chewing Yes	217	14	6.5	325	40	12.3
No	67	6	9.0	149	18	12.1

Diet	Vegitarian	177	15	8.5	321	41	12.8
	Mixed	107	5	4.7	153	17	11.1
Total Prevalence		**284**	**20**	**7.0**	**474**	**58**	**12.2**

Table 4. Mean number of working hours, hours for which masks and glasses were used and mean morning blood pressure, of workers who worked and used face mask and eyeglasses for all six days of intervention (n=19).

Day of intervention	Mean no. of hours Worked	Mean no. of hours masks used	Mean no. of hours glasses used	Mean Systolic Blood Pressure (mm Hg)	Mean Diastolic Blood Pressure (mm Hg)
D1	6.2±0.5	3.9±1.0	4.8±0.8	127.8 ± 11.1	80.7 ± 8.8
D2	10.0±1.4	5.5±1.5	6.5±1.6	127.8 ± 11.8	80.6 ± 12.8
D3	9.7 ± 1.8	4.6±1.3	5.2±1.9	123.4 ± 10.3	76.4 ± 8.6
D4	7.9 ± 0.5	4.4±1.9	4.8±1.3	117.5 ± 9.9	62.6 ± 7.8
D5	9.3 ± 0.9	4.2±1.1	4.5±0.9	113.8 ± 7.0	63.8 ± 8.0
D6	9.1 ± 1.3	4.8±1.4	5.2±1.5	114.6 ± 6.5	63.0 ± 5.5
Total	**8.7 ± 1.7**	**4.6±1.5**	**5.1±1.5**		

Table 5. Systolic as well as diastolic blood pressure of these workers began declining on the third day, continued to decline on forth day but remained stationary thereafter.

Day of intervention	Mean Systolic Blood Pressure (mm Hg)	p - value	Mean Diastolic Blood Pressure (mm Hg)	p - value
D1	127.8 ± 11.1		80.7 ± 8.8	
D2	127.8 ± 11.8	0.982	80.6 ± 12.8	0.948
D2	127.8 ± 11.8		80.6 ± 12.8	
D3	123.4 ± 10.3	0.035*	76.4 ± 8.6	0.156*
D3	123.4 ± 10.3		76.4 ± 8.6	
D4	117.5 ± 9.9	0.027*	62.6 ± 7.8	0.000*
D4	117.5 ± 9.9		62.6 ± 7.8	
D5	113.8 ± 7.0	0.077	63.8 ± 8.0	0.549
D5	113.8 ± 7.0		63.8 ± 8.0	
D6	114.6 ± 6.5	0.677	63.0 ± 5.5	0.651

* Difference significant; Student‘t’ test (two tail) was applied.

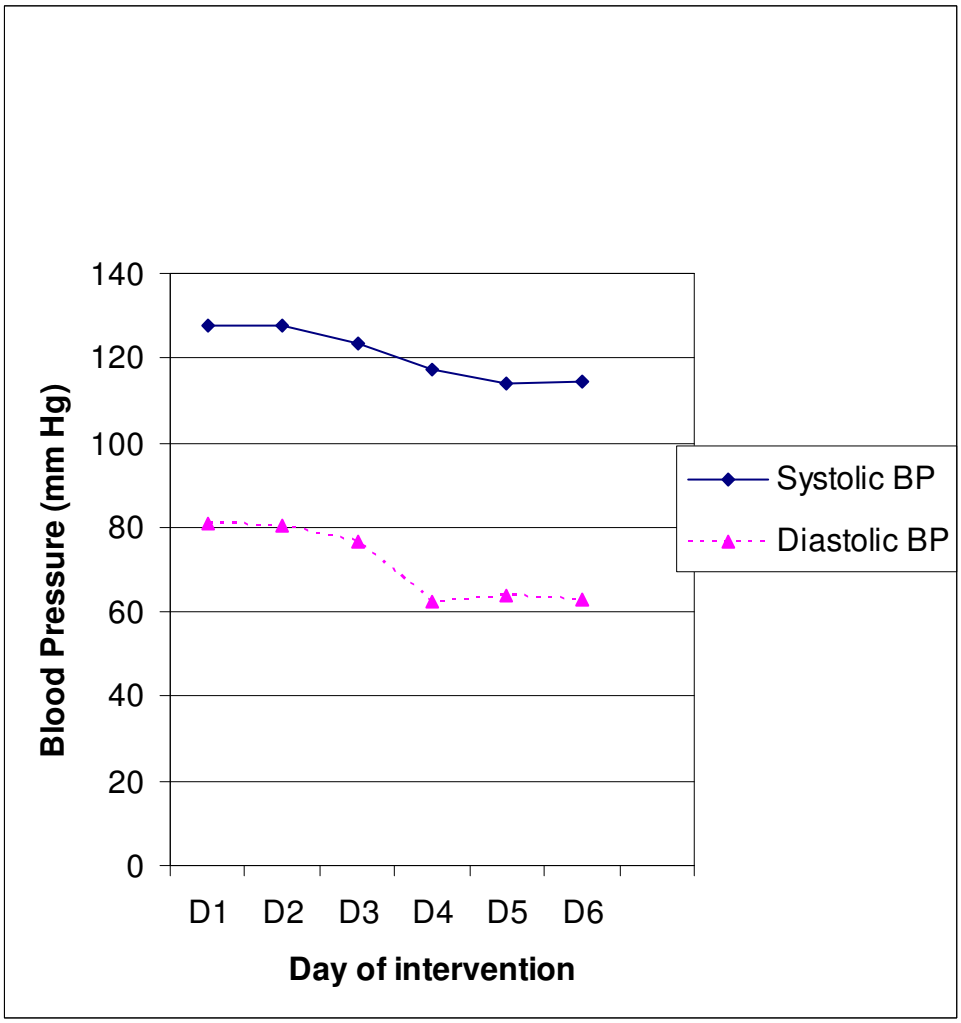

Figure 1. Blood Pressure of non-brine workers declined by use of masks and glasses.