RESEARCH ARTICLE

Prevalence of undernutrition and anemia among male brick workers in north 24-Parganas district of West Bengal, India

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ABSTRACT

Objective: The study was conducted to assess the nutritional and anemia status of adult male brick workers of North 24- Parganas district of West Bengal, India. *Methods*: 72 randomly selected male brick workers were taken for this cross-sectional study. The nutritional status was assessed from the reference values of body mass index (BMI) and mid-upper arm circumference (MUAC). The 24-hour recall method was used for dietary assessment. Hemoglobin concentration and hematocrit value (HCT%) were measured, and the grade of anemia was assessed. *Results*: About 34.5 and 40.12% of brick workers were found to be undernourished in terms of BMI and MUAC, respectively. About 91.67% of brick workers were found to be anemic. Consumption of calories and protein and the percent intake of vitamins and minerals were found to be lower than the recommended daily allowance (RDA). SES of brick workers was significantly correlated with their BMI (p <0.05), MUAC (p <0.05), HCT% (p <0.01) and hemoglobin concentration (p <0.001). *Conclusion*: The present study revealed that a high prevalence of undernutrition and anemia exists in surveyed brick workers. SES and insufficient dietary intake seemed to be the significant determinants of their vulnerable nutritional status and anemia.

Keywords: Brick workers, Undernutrition, Anemia, Body mass index, Mid upper arm circumference.

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INTRODUCTION

India is the second largest brick-producing country in the world, with over 240 billion bricks produced annually[1]. Due to the increasing demand for bricks in the housing and infrastructure sectors, the industry continually expands to meet the shortage. More than 150,000 brick units directly employ over 8 million people to meet their demand. In West Bengal, India, nearly 10,000 brick kilns are operated by over 1.5 million brick kiln workers. Despite the significant number of families involved, this occupation remains largely unstructured and undocumented in the public domain. As the city of Kolkata expanded, the surrounding areas, including the districts of Howrah, Hooghly, South and North 24 Parganas, became suitable locations for brickfields[2].

It is widely recognized that brick kiln workers suffer from poor health and limited access to medical care. The bad housing conditions of brick kiln workers are located close to brick manufacturing facilities. These brick workers are characterized by illiteracy, poverty and nutritional problems. The health and nutritional status of these workers in India remains unreported excepting a few studies. The nutritional status of brick workers was reported in different states of India like Punjab[3], Maharashtra[4,5], Uttar Pradesh[6] and Assam.[7] However, the nutritional status of brick workers in West Bengal was not investigated sufficiently. The body mass index (BMI) has been known as a measure of nutritional status in the Indian population since the last century.[8] In West Bengal, Bandhopadhyay & Sen (2014) conducted a study in South 24-Parganas district and found that about 58% of female brick workers were suffering from undernutrition as measured by body mass index (BMI)[9]. Later, Das (2018) reported that a high percentage of undernutrition (68.96%) prevailed among preadolescent brick workers of Hooghly district[10]. The brick industry in North 24-Parganas district is the second largest in West Bengal, with over 3 lakh brick workers employed in around 2500 brick kilns in this district[11]. The nutritional status of male brick workers in West Bengal, particularly in north 24-Parganas, has not been investigated in recent times. The most objective and quantitative information about nutritional status can be obtained through hematological or biochemical tests. According to a report, symptoms of nutritional deficiency initially manifest as hematological and biochemical abnormalities, followed by cell or organ impairments and the eventual establishment of clinical malnutrition. Despite anthropometric research indicating common undernutrition among these workers, there has been no study on the hematological parameters of brick workers in India, especially in West Bengal.[9,10] Measurement of hemoglobin concentration is usually used as the primary

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indicator for describing different kinds of nutritional anemia.[12,13] An association between undernutrition and hemoglobin concentration has been reported in adult populations[14,15]. A study by David *et al*. (2022) indicated that anemia is a major health problem among male brick kiln workers in Islamabad[16], Pakistan. In a study by the International Labour Organization, a high occurrence of anemia (42%) was found in child brick kiln workers across four countries[17]. Measuring the hemoglobin concentration in these workers may provide insight into the influence of factors such as of nutrition, socioeconomic status and other variables on their hemoglobin levels. Assessing the dietary intake of these workers is also important for understanding their nutritional status and identifying any specific nutrient deficiencies. However, there is a lack of research on the food intake of brick workers in West Bengal. Therefore, the current study has been conducted on adult male brick workers of North 24- Parganas of West Bengal to evaluate their nutritional status by measuring some anthropometric parameters and dietary intake. The study also aims to assess the prevalence of anemia status by measuring hemoglobin concentration and examining the association between nutritional and socioeconomic status and hemoglobin levels.

METHODOLOGY

Study Population

The study was cross-sectional and involved 72 male brick workers from three randomly selected brick kilns in the Basirhat areas of North - 24 Pgs District, West Bengal, India. Additionally, 34 male subjects (age: 39.04 $\pm$ 2.47) working in an office setting with minimal hand-intensive work were randomly selected as the control group. Workers with disabilities, those who had undergone major surgical operations, or those suffering from systemic diseases that could affect their measurements were excluded from the study. The socio-demographic profiles of the workers were confirmed with the respective brick industries' managers. The study was approved by the institutional human ethical committee (Medical College, Kolkata, Ref. No: MC/KOL/IEC/NON-SPON/181/12-2020) and was conducted in accordance with the revised ethical guidelines for human experimentation of the Helsinki Declaration.[18]

Socioeconomic Status

The socioeconomic status (SES) of brick workers was evaluated using the updated Kuppusswami scale.[19] The subjects' families provided socioeconomic information through a designed questionnaire.

Anthropometrics & Body Composition Parameters

The anthropometric data of brick workers and control participants, such as height (cm), weight (kg), and mid-upper arm circumference (MUAC in cm), were measured using a standard technique.[20] The BMI of each subject was calculated using the formula: (BMI in kg/m^2) = Weight (kg) / Height (m^2).

Assessment of Nutritional Status

The nutritional status of brick workers was assessed using the reference values of BMI[21] and MUAC.[22] The degree of undernutrition was also determined. Individuals with a BMI less than 18.5 (kg/m^2) and a MUAC of less than 23 cm were categorized to be undernourished.

Dietary Assessment

A standardized set of cups designed for local conditions was used in the 24-hour recall method to evaluate nutritional intake. The staff's food consumption over the previous 24 hours was recorded. The food intake table from "Nutritive values of Indian foods" was used to calculate the amount of each nutrient. Nutrient amounts were calculated using the food intake table from "Nutritive Values of Indian Foods." Each employee's adult consumption unit (ACU) was determined, and the amount of nutrient intake per ACU was calculated. The levels of the nutrients consumed were then compared to the recommended daily allowances (RDAs) as per the Indian Council of Medical Research (ICMR). The total amount of each preparation was noted using standardized cups, and all values underwent statistical analysis. The nutritive and calorific values of various foods consumed by each employee were estimated from the tables of nutritive values of Indian foods and compared with the RDAs for Indians as per ICMR.[23,24]

Hemoglobin concentration & assessment of anemia status

The hemoglobin concentration and hematocrit value in percentage (HCT%) were measured using an automated machine (Quick-Check, China) via the finger prick method[25]. The status of anemia was assessed based on the classification of the World Health Organization[26]. Subjects with hemoglobin values between 11 to 12.9 gm% were considered mildly anemic, those with values between 8 to 10.9 gm% were considered moderately anemic and those with values < 8 gm% were considered severely anemic. Additionally, a peripheral blood smear was obtained from control subjects and brick workers, and it was stained with Leishman stain for morphological studies using a light microscope.

Statistical Analysis

The mean and SEM were calculated on various anthropometric and sociodemographic data. A student's t-test with an alpha level of 0.05 was performed to determine if there was a significant difference in the anthropometric, body composition, and hemoglobin parameters between the brick workers and the control group. Pearson's correlation coefficient was used to assess the association between anthropometric and sociodemographic, socioeconomic, and nutrient consumption. Statistical analysis was conducted using the statistical package for the social sciences (SPSS software, Version 20.0).

RESULTS

Socio-economic status

About 81.94% of brick workers are in the lower socioeconomic category (score <5), while 18.06% are in the upper-lower category (score 5–10) (Table 1).

Socio-demographic Characteristics

Table 2 presents the socio-demographic characteristics of the surveyed brick workers. On average, the workers have about 13 years of working experience and work for 8 hours per day. The workers are divided into four groups: 33.34% are brick makers, 25.34% are involved in brick loading, 16.67% are engaged in brick burning, and 24.67% are involved in unloading work. Additionally, 33.34% of brick workers are smokers and 8.34% are alcoholics.

Anthropometric and Body Composition Variables, and Hb Concentration

Anthropometric measurements such as height, weight, MUAC, BMI, as well as hemoglobin concentration and HCT% of brick workers are detailed in Table 3. The hemoglobin concentration and HCT% of brick workers are significantly lower (p <0.01) compared to that of control subjects.

Nutritional Status

The prevalence of undernutrition among brick workers in terms of BMI (kg/m^2) and MUAC (cm) is depicted in Figure 1.

Table 1: Socioeconomic status of brick workers and control subjects

Socioeconomic class	*Brick workers N (%)*	*Control N (%)*
Upper	-	-
Upper-middle	-	-
Lower-middle	-	-
Upper-lower	13 (18.06)	9 (26.47)
Lower	59 (81.94)	25 (73.53)
Total (%)	72 (100)	34 (100)

N = number of brick workers

Table 2: Socio-demographic characteristics of brick workers

Variables	Brick workers (n = 72)
Age (years)	38.62 ± 2.04
Job category	
Making	33.34%
Loading	25.34%
Burning	16.67%.
Unloading	24.67%
Work experience (years)	13.62 ± 1.69
Working duration per day (hour)	8.12 ± 0.24
Smoking	
Smoker	33.34%
Non-smoker	66.66%
Alcohol consumption	
Alcoholic	8.34%
Non-alcoholic	91.66%

Table 3: Mean and standard error of mean of different anthropometric and body composition variables of control and brick workers (**p<0.01, ***p<0.001).

Variables	*Control (Mean ± SE)*	*Brick workers (Mean ± SE)*
Height (cm)	159.28 ± 1.75	161.81 ± 1.64
Weight (kg)	57.33 ± 2.06	56.53 ± 1.39
BMI (kg/m^2)	22.61 ± 0.87	21.48 ± 0.54
MUAC (mm)	25.7 ± 0.57	24.6 ± 0.98
BF (%)	24.84 ± 1.42	22.09 ± 1.27
Hb con. (gm%)	12.46 ± 0.57**	± 0.28
HCT (%)	39.57 ± 0.41***	31.89 ± 0.86

Table 4: Percentage of erythrocytes with morphological abnormalities as observed from Light microscopy among Brick kiln workers. A total of 100 cells were counted from each sample. (***p < 0.001)

Abnormal Erythrocytes	*Control (mean ± SD) (n = 10)*	*Brick kiln worker (Mean ± SD) (n = 22)*
Microcytes	3.32 ± 0.122	23 ± 0.705***
Tear Drop Cell	00	09 ± 0.603***

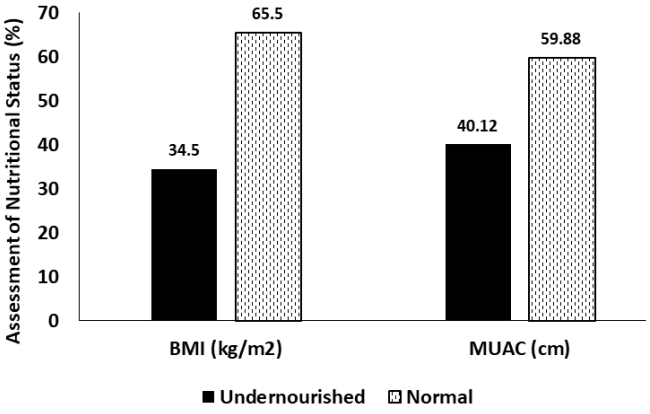

Figure 1: Percentages of undernourished and normal brick workers according to BMI (kg/m^2) and MUAC (cm)

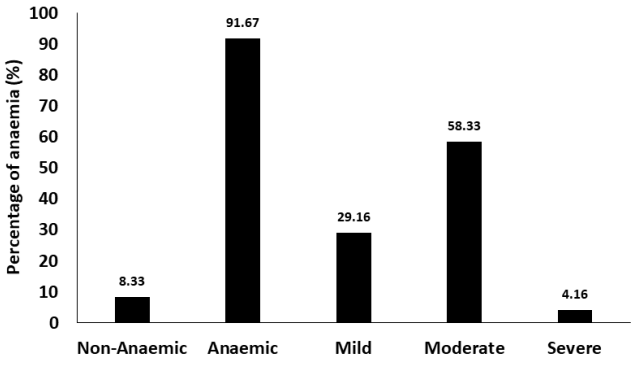

Figure 2: Percentages of non-anemic, overall anemic and different categories of anemic brick workers according to hemoglobin concentration (gm%)

Table 5: Correlation between anthropometric and body composition parameters and socio-demographic factors.

Anthropometric & Body composition parameters	*Socio-demographic factors*				*SES*	*Iron intake*	*Protein intake*
	Work experience	*Work duration*	*Smoking*	*Alcohol intake*			
BMI	0.29	0.26	0.31	0.02	56**	0.29	0.27
MUAC	0.11	0.32	0.15	0.23	0.39*	0.31	0.52**
BF%	0.31	0.11	0.18	0.08	0.45*	0.41*	.049**
Hb Conc (gm%)	0.45*	0.38*	0.24	0.27	0.84***	0.71***	0.64***
HCT (%)	0.42*	0.33	017	0.11	0.47*	0.66**	52**

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

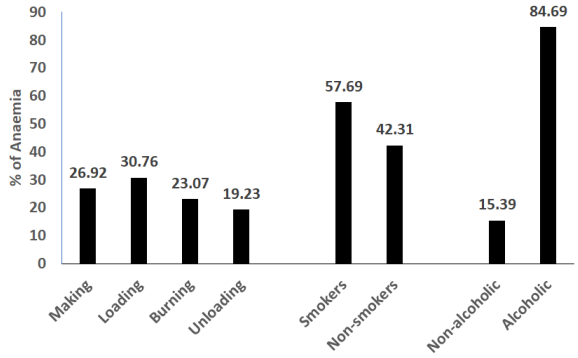

Figure 3: Percentage of anemia in different socio-demographic categories of brick workers

Approximately 34.5 and 40.12% of brick workers are identified as undernourished based on BMI and MUAC, respectively.

Anemia Status

Approximately 91.67% of brick workers are found to be anaemic, with 58.33% in the moderate category and 4.13% in severe category (Figure 2). Figure 3 illustrates a higher prevalence of anaemia among smokers (57.69%), alcoholic workers (84.69%) and workers involved in loading jobs (30.76%). The number of microcytic and teardrop RBCs is significantly higher ($p < 0.001$) in brick workers compared to control subjects (Table 4). Images of light microscopy (400X) of peripheral blood smears of brick kiln workers show the presence of microcytic RBC (Figure 4ii) and tear drop cells (Figure 4iii).

Nutrients Intake

Figure 5 shows that the calorie and protein intake of brick workers is lower than the RDA set by ICMR. Similarly, the intake of vitamins and minerals consumed by male brick workers is also inadequate. The percentage intake of vitamins and minerals by brick workers is also lower compared to that of RDA.

Correlation Study

SES of brick workers is significantly correlated with their BMI (p <0.05), MUAC (p <0.05), and hemoglobin concentration (p <0.001). Hemoglobin concentration and HCT% of brick workers are found to be significantly (p <0.05) correlated with their work experience and work duration per day (Table 5). Both iron and protein intake by the workers are also significantly correlated with hemoglobin concentration (p <0.001) and HCT% (p <0.01).

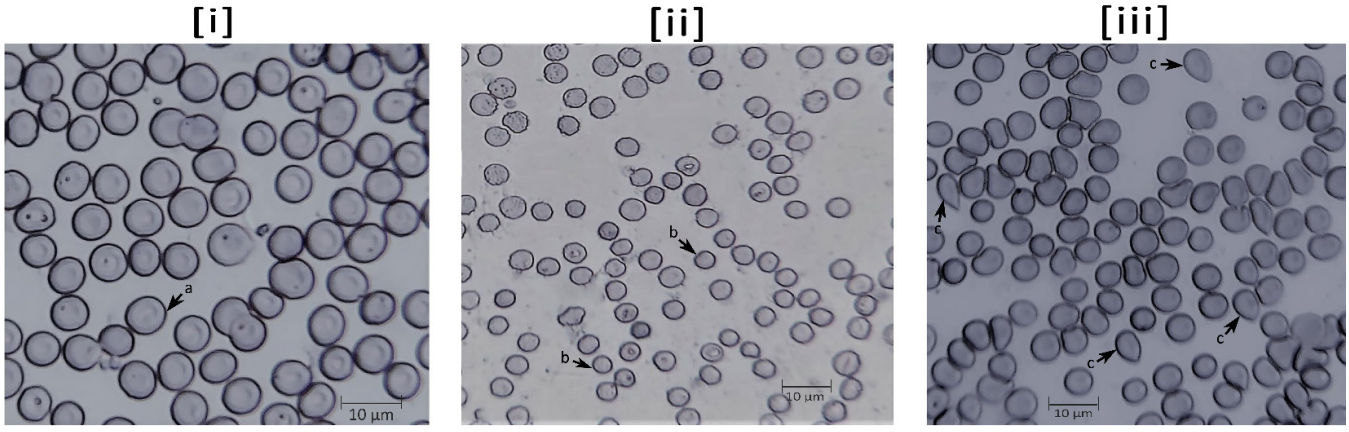

Figure 4: Light microscopy images (400X) of peripheral blood smear of Brick kiln workers. [1] Represents the normal blood smear with proper discoid RBC's marked as **a** [2] Represents blood smear of Brick kiln worker which shows presence of microcytic RBC marked as **b** [3] Represents blood smear of Brick kiln worker which shows presence of Tear Drop cells marked as **c.**

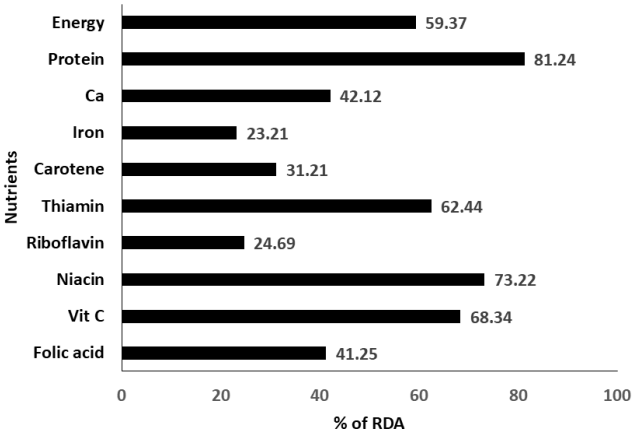

Figure 5: Mean intake of nutrients as % of recommended daily allowance (RDA) in brick workers

DISCUSSION

The health and nutritional status of the surveyed brick workers, as assessed by BMI and MUAC, showed that undernutrition was prevalent in these workers. BMI is considered the most useful and popular parameter for assessing nutritional status in adults. Also, according to the World Health Organization (WHO), there is a direct relationship between BMI and the risk of chronic diseases in the subjects[27]. In this study, the mean BMI of brick workers fell within the normal range and was found to be higher than that of brick workers in Hooghly district (17.9 kg/m^2),[9],Paschim Medinipur district (18.35 kg/m^2)[28], Birbhum district (18.2 kg/m^2),[29] Murshidabad district (20.11 kg/m^2)[30] of West Bengal, as well as Delhi (20.95 kg/m^2)[31] but lower than that of brick workers in South 24 Parganas (23.84 kg/m^2) of West Bengal.[10] MUAC has also been used in developing countries as a useful tool for nutritional assessment and to identify malnutrition and the threat of morbidity in adults.[32,33] Similarly to BMI, the MUAC of surveyed brick workers was found to be higher than that of women brick workers (21.9 cm) in Medinipur district[28] but similar (24.53 cm) to that of male brick workers in Murshidabad district[30] of West Bengal. However, the difference in the pattern of BMI and MUAC between surveyed brick workers and other brick workers may be due to different socio-demographic characteristics of the communities, environmental factors as well as ethnic differences.

The study found that 34.5% of surveyed brick workers were undernourished based on their BMI, while 40.12% were undernourished based on their MUAC. This high prevalence of undernutrition not only reflects the poor health status of the workers but also indicates compromised immunity, making them more susceptible to respiratory disorders, allergies, musculoskeletal problems, and neurological issues.[34,35] The percentage of undernutrition based on BMI was lower than in other areas such as Hooghly district of West Bengal (91.3%)[10] and (58%)[9] Thane district of Maharashtra (44.6%)[4], and Jorhat district of Assam (38.3%)[7], but higher than in Murshidabad district of West Bengal (22%)[30] and Rajasthan (15.85%)[36]. Similarly, the prevalence of undernutrition based on MUAC was lower than in Assam (52.3%) but higher than in Murshidabad district of West Bengal (23.4%).[30] As the surveyed brick workers belong to a lower socioeconomic class, their vulnerable nutritional status may be related to their poor socioeconomic condition. Additionally, environmental exposure to metals in their working areas may also contribute to their undernutrition.[37,38]

The prevalence of undernutrition among surveyed brick workers, as assessed from anthropometric measurements, is supported by the results of their dietary intake. The study revealed that the nutrients consumed by brick workers in the surveyed region were found to be low compared to the RDA. The workers of the current study also consumed a lower quantity of energy and protein compared to the RDA. Similar results were found in brick workers of the Ludhiana district of Punjab (Kaur *et al*. 2008) and Cox Bazar district of Bangladesh.[39] The degree of deficiency was comparatively higher in micronutrients such as iron, calcium, vitamin A, free folic acid and riboflavin. It is evident from the present observation that there is a steady inadequacy in food and nutrient intake among surveyed brick workers. The lower intake of energy and protein compared to RDA is mainly due to the lower intake of cereals in addition to very low consumption of fats and oils, and protein-rich foods such as meat products and pulses. This inadequacy is reflected in the higher prevalence of undernutrition among surveyed brick workers. The poor consumption of foods and nutrients among surveyed workers may be associated with their poor socioeconomic conditions.

The current study observed that all anthropometric and body composition parameters (BMI and MUAC) and hemoglobin concentration are significantly linked to socioeconomic status (SES). This suggests that a lower SES is likely to be a significant factor in determining vulnerable nutritional and anemia status, as well as insufficient dietary consumption among the surveyed brick workers.

The results of the study showed that brick workers had a low level of hemoglobin concentration and HCT%. The mean hemoglobin concentration of these workers was lower than that of Pakistani brick workers (12.5 gm%)[17] A high percentage (91.67%) of surveyed brick workers were found to be suffering from anemia which was similar to the results (90.5%) reported by Gogoi and Hazarika (2016) in brick workers of Jorhat district of Assam[7], but higher than the brick workers (51%) of Tripura, a state in north-east India[40]. The low level of hemoglobin concentration and HCT% might be associated with a high prevalence of anemia in these workers, which could be linked to insufficient dietary intake of iron and protein. The study showed that hemoglobin concentration was found to be significantly correlated with low intake of iron and protein. Poor socioeconomic conditions were also likely to be significant determinants for the anemia status, as they were found to be linked with the insufficient dietary intake of surveyed brick workers. The incidence of

heavy metals produced in the brick kiln atmosphere may be another causative factor for the prevalence of anemia among surveyed brick workers. Some earlier studies showed the detection of heavy metals in the blood of brick workers and its relation to low hemoglobin levels.[41,42] The study also found a variation in the percentage of anemia among different job categories of brick workers, as well as their smoking and drinking habits.

The study found that brick kiln workers have morphologically altered red blood cells, such as microcytic red blood cells and teardrop cells. The presence of microcytic red blood cells (RBCs) suggests microcytic anemia, often caused by iron deficiency. The survey's correlation analysis showed a strong relationship between hemoglobin concentration and the consumption of iron and protein. The absence of iron reserves in the bone marrow is the standard for distinguishing iron deficiency from other microcytic diseases. Darcocytes, or teardrops of red blood cells, can also be observed in splenic anomalies and vitamin B_{12} insufficiency. The presence of darcocytes in the peripheral blood smear of surveyed brick workers may indicate infiltration of the bone marrow by fibrosis.[43,44] Further research and clinical evaluation are needed to determine the precise reason for these morphological abnormalities in red blood cells among brick kiln workers. It's likely that exposure to specific environmental elements, such as dust or chemicals at the workplace, maybe a factor in these alterations.

The present study showed that the male brick workers surveyed suffered from undernutrition, which was evident from their insufficient dietary intake. The study also reported that a significant percentage of the surveyed brick workers were suffering from anemia. The dietary insufficiency of iron and the presence of microcytic RBCs suggested that these workers may be suffering from iron deficiency anemia.

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PEER-REVIEWED CERTIFICATION

During the review of this manuscript, a double-blind peer-review policy has been followed. The author(s) of this manuscript received review comments from a minimum of two peer-reviewers. Author(s) submitted revised manuscript as per the comments of the assigned reviewers. On the basis of revision(s) done by the author(s) and compliance to the Reviewers' comments on the manuscript, Editor(s) has approved the revised manuscript for final publication.