Original Article

Haematological profiles of Sudanese Traditional Bakery workers exposed to biomass burning hazards

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Abstract

Background :
Approximately one-third of the world's population in the developing countries are still dependent on Solid Biomass Fuel for cooking, heating and other household activities. This study aims to determine the Haematological profiles of Sudanese Traditional Bakeries workers exposed to wood-burning and compared with the non-exposed.

Methodology :
A case-control study conducted at Kosti, Rabak, and Kenana, during the middle of 2017. Two hundred participants recruited in this study. One hundred traditional bakeries workers represented the case group and another hundred non-exposed apparent healthy matching individuals were chosen as a control group. 2.5 ml venous blood was collected into an EDTA container and the two groups were exposed to full blood counts (FBC).

Results :
The mean of Haemoglobin, Haematocrit, Mean Cell Volume, Mean Cell Haemoglobin Mean Corpuscular Haemoglobin Concentration, Platelet counts, and Neutrophil count values among bakeries group compared to control group were statistically significantly decreased (12.58 g/dl (±2.15) vs. 15.5 g/dl (±0.95); 42.71 l/l (±6.14) vs. 44.72l/l (±4.15);83.49 fl (±6.43) vs. 89.18 fl (±7.15); 27.72 pg (2.83) vs. 29.41 pg (±1.88); 30.75% (±2.64) vs. 32.33% (±2.26); 205.29×10^3/l (±51.49) vs. 238.11×10^3/l (±59.56); 49.59% (±16.43) vs. 57.36% (±13.93) respectively. The mean of TWBC counts 6.77×10^3/l (±1.71) vs. 6.17×10^3/l

الملخص

مقدمة:
لا يزال حوالي ثلث سكان العالم في البلدان النامية يعتمدون على الوقود الحيوي لأغراض الطهي. والتدفئة وغيرها من الأنشطة المنزلية المختلفة وتهدف هذه الدراسة لمعرفة صورة الدم الكاملة للعاملين في المخابز السودانية التقليدية المعرضين للدخان الناتج من استخدامهم حرق الأخشاب ومقارنتها بصورة الدم الكاملة مع أشخاص أصحاء غير معرضين لدخان الأخشاب.

طريقة البحث:
أجريت الدراسة الحالية في السودان في مدن كوستي وربك وكنانة خلال منتصف العام ٢٠١٧ بمشاركة مائة من عمال المخابز التقليدية مثلوا مجموعة الدراسة، وتم اختيار مائة شخص آخر كمجموعة ضابطة متطابقة مع مجموعة الدراسة في الجنس والعمر حيث تم عمل صورة دم كاملة للمجموعتين.

النتائج:
أظهرت نتائج الدراسة أن متوسط قيمة الهيموغلوبين، الهيماتوكريت، متوسط حجم الخلية، متوسط تركيز الهيموغلوبين في الدم، تركيز الهيموغلوبين وتعداد الصفائح الدموية لدي عمال المخابز التقليدية أقل وذات دلالة إحصائية جوهرية مقارنة بالمجموعة الضابطة بينما أظهر متوسط تعداد الخلايا الليمفاوية ومتوسط تعداد كريات الدم البيضاء قيم أعلي وذات دلالة إحصائية جوهرية لدي عمال المخابز التقليدية في حين لم يتم ملاحظة أي

(±1.50) and Lymphocyte counts 36.21% (±13.52) vs. 29.98% (±5.70) were statistically significantly increased in bakeries. No significant differences were observed in the RBC counts between the study group and control group.

Conclusion :
There was a clear and significant effect of exposure to wood-burning smoke on most of the haematological values, among workers of the traditional bakeries.

Keywords :
Wood-burning, RBCs counts, Hb, TWBCs counts, Platelet count, Sudan.

فروق ذات دلالة إحصائية جوهرية بين المجموعتين في متوسط تعداد كريات الدم الحمراء. وخلصت الدراسة إلى تأثير واضح وكبير لصورة الدم الكاملة لدي العاملين بالمخابز التقليدية نتيجة التعرض للدخان الناتج من حرق الأخشاب المستخدم في المخابز.

Introduction:

Biomass burning has its origins since ancient times. In spite of mass urbanization of the world, a large section of residents of rural areas in developing countries continue using biomass burning in Traditional Cook Stoves (TCS). [1, 2] Most rural households (approximately one-third of the world's population in developing countries- around three billion people) are still dependent on Solid Biomass Fuel (SBF) from materials including wood, sawdust, crop residue, dunk cake or coal for cooking, heating and other household energy needs.[3-6] Dependence on SBF (40%) leads to Indoor Air Pollution (IAP) which is recognized as a major threat to human health. [2, 7] Short-term exposure to emissions from wood combustion is known to be harmful to health from the combustion of fossil fuels. These include at least 28 pollutants in smoke from solid fuel use which are toxic, including 14 carcinogenic compounds and 4 cancer-promoting agents. [5] Several health-hazardous pollutants released by Burning of SBFs included Particulate Matters (PM), which have been declared carcinogenic by the International Agency for Research on Cancer. Examples are Carbon Monoxide (CO), Volatile Organic Compounds (VOCs) and, certain hydrocarbons including Polycyclic Aromatic Hydrocarbons (PAHs) in the environment. [8-10] Numerous studies have mentioned that, (PM2.5) product of incomplete SBF combustion, is a component associated with climatic impacts and health effects. [3, 11] Concerning the systemic effects of human health, air pollution represents around 6% of the burden of disease. However, the World Health Organization (WHO) estimates that more than 4.3 million deaths annually are caused by smoke-induced diseases. This is more than deaths caused by tuberculosis and malaria, which makes it one of the leading causes of deaths worldwide. According to the report by World Health Organization (WHO) in 2018, high levels of exposure to PM2.5 may be responsible for approximately 3.8 million premature deaths annually which includes deaths due to respiratory and heart diseases. [12] Also, CO is a colourless gas which has serious effects, causing tissue hypoxia due to high binding capacity to haemoglobin; continuous exposure may result in neuropsychiatric impairment. [13-15] Workers in traditional bakeries, women, and children are the most vulnerable group being exposed to burning emissions in the kitchen area during cooking hours. [7, 8] Therefore, the impact of the concentration of pollutants from indoor biomass burning depends on many factors such as stove characteristics, kitchen characteristics, type and quantity of fuel, method of cooking and ventilation influencing the household indoor air quality (IAQ). [16, 17] Indoor air pollution from biomass combustion, such as exposure to wood smoke represent a major source of mortality and morbidity worldwide. It has been associated with irritation of the mucous

membranes, physiological and neurological effects in humans and may be responsible for reduced lung function, increased risks of cardiovascular disease, stroke, lung cancer, chronic obstructive pulmonary disease, acute lower respiratory infections, ischemic heart disease, low birth weight, preterm birth, stillbirth, stunting, cataracts, and all-cause mortality. [5, 18-22] Most of the Sudanese in rural areas use biomass fuel (mainly wood) in their traditional bakeries. So, the current study aimed to determine the alterations and changes with regards to haematological profiles to detect if there was any significant difference between traditional bakery workers, who worked more than three continuous years using wood and were exposed to burning smoke and healthy individuals. It is important to note that, this type of study has not been conducted in Sudan before.

Methods:

Study Design and study setting: A case-control study was done at White Nile State, Kosti, Kenana and Rabak towns, Sudan, from the period of June to November 2017 in order to study the effects of exposure to wood-burning smoke on complete blood counts among Sudanese traditional bakery workers exposed to burning smoke for more than three consecutive years. Participants and sample size: One-hundred traditional bakers were chosen randomly according to Inclusion and Exclusion Criteria to participate in this study as a case group and another hundred healthy age and sex-matched individuals were chosen as a control group.
Inclusion and Exclusion Criteria: All bakery workers working in Kosti, Rabak; and Kenana being exposed to wood-burning smoke for more than three continuous years were included in this study. Participants who had cardiovascular disease, presence of concurrent blood diseases, concurrent drug usage effect on Complete blood counts (CBC), smokers, alcoholism, children, work period less than or equal to consecutive three years and those who refused to participate were excluded.
Data Collection: Structured questionnaire was used to collect data. It included personal and clinical information along with laboratory investigations. *Laboratory Analysis:* 2.5ml venous blood samples were collected from each participant into Ethylene Diamine Tetra Acetic Acid (EDTA) containers, labelled, mixed, and checked for absence of clots, and examined immediately for full blood counts (FBC) using automated haematology analyser (XK-21 Sysmex®, Tokyo, Japan). Peripheral blood films were stained with Giemsa for morphology and differential counts were done microscopically. *Statistical analysis:* Laboratory and demographic data were analysed by Statistical Package for the Social Sciences (SPSS), IBM version-25. Mean, standard deviation and Frequency distribution were performed. The comparison was done by applying two-tailed Student's t-test to know the difference between traditional bakery workers' haematological values and the healthy control group laboratory results. The alpha error of 0.05 and P-value ≤ 0.05 was considered as a level of significance. *Ethical considerations:* Each participant completed the informed consent form before the collection of specimen. Ethical approval was obtained from the research and ethics committee at the University of El Imam El Mahdi, Faculty of Medical Laboratory Sciences.

Results:

100% of the study participants were male because normally females in Sudan don't work in bakeries and fuel stations. [27] The findings of the current study showed that, 50% of the study group and controls were between 30-39 years old, 32% between 20-29 years old, and the remaining 18% between 40-49 years old. (Table 1) The results of haematological pa-

rameters indicated that the mean of Hb, HCT, MCH, MCHC, MCV, platelet counts, and Neutrophil count values among bakers' group were statistically significantly decreased compared to the control group. The mean of the Haemoglobin (Hb) (12.58±2.15 g/dl vs. 15.15±0.95 g/dl ;P<0.001), Haematocrit (HCT) (42.71±6.14 l/l vs. 44.72±4.15 l/l ;P<0.001), Mean Cell Haemoglobin (MCH) (27.72±2.83 pg vs. 29.41±1.88pg; P=<0.001), Mean Cell Haemoglobin Concentration (MCHC) (30.75±2.64%vs. 32.33±2.26%; P=<0.001), Mean Cell Volume (MCV) (83.49±6.43fl vs. 89.18±7.15 fl; P<0.001), platelet counts (205.29±51.49×10^3/l vs. 238.11±59.56×10^3/l; P=<0.001), Neutrophil count (49.59±16.43% vs. 57.36±13.93% ;P=<0.001).

(Table 2, 3, 4). However, the mean of TWBCs counts (6.77±1.71×10^3/l vs. 6.17±1.50×10^3/l; P=0.007), and the mean of lymphocyte counts (36.21±13.52% vs. 29.98±5.70%; P=<0.001), were statistically significantly increased in bakers group (Table4). The mean of Red Blood Cells (RBCs) counts (4.89±0.6×10^{12} vs. 4.90±0.42×10^{12}; P<0.001), had no statistically significant difference between bakers and apparently healthy control group (Table 3). The blood morphology of the traditional bakery workers showed that,37% of the participants' RBCs had a normocytic normochromic picture, 34% normal with stomatocyte cells, 17% dimorphic picture, 6% normal with target cells, and 4% normal with spherocytes and 2% showed a microcytic hypochromic picture. (Table 5)

Table 1: Traditional bakers (exposed to wood burning) and controls age and address

Parameter	Category	Frequency	percent
bakery workers' age range	20-29	32	32%
	30-39	50	50%
	40-49	18	18%
	Total	100	100%
bakery workers' Addresses	Kosti	63	63%
	Rabak	21	21%
	Kenana	16	16%
	Total	100	100%

Table 2: Haemoglobin concentration (Hb) and haematocrit blood test (HCT) values among Traditional bakers (exposed to wood burning) and controls.

Parameter	Study group traditional bakeries n=100				Control group apparent healthy individuals n=100				t- value	P-value*
	Category	Frequency	percent	Category	Category	Frequency	percent	Mean ±SD		
Hb concentration	12-17 g/dl	52	52%	12.58±2.15 g/dl	12-17 g/dl	87	87%	15.15±0.95 g/dl	10.924	<0.001
	<12 g/dl	48	48%		<12 g/dl	9	9%			
	>17 g/dl	0%	0%		>17 g/dl	4	4%			
	Total	100	100%		Total	100	100%			
HCT	45.5 l/l-41.5 l/l	59	59%	87%	45.5 l/l-41.5 l/l	93	93%	44.72±1.05 l/l	5.605	<0.001
	<41.±.5 l/l	37	37%		<41.±.5 l/l	5	5%			
	>45±.5 l/l	4	4%		>45±.5 l/l	2	2%			
	Total	100	100%		Total	100	100%			

*Significance at the level ≤0.05

Table 3: RBCs counts and red cell indices (MCV, MCH, and MCHC) values among Traditional bakers (exposed to wood burning) and controls.

Parameter	Study group traditional bakeries n=100				Control group apparent healthy individuals n=100				t- value	P-value*
	Category	Frequency	percent	Mean ±SD	Category	Frequency	percent	Mean ±SD		
RBCs counts	3.8-5.5 × 10^{12}	52	52%	4.89±0.61 ×10^{12}	3.8-5.5 × 10^{12}	85	85%	4.90±0.42 × 10^{12}	0.068	0.946
	<3.8× 10^{12}	31	31%		<3.8× 1012	12	12%			
	>5.5 × 10^{12}	17	17%		>5.5 × 1012	3	3%			
	Total	100	100%		Total	100	100%			
MCV	92.0±9 fl	48	48%	83.49±6.43 fl	92.0±9 fl	87	87%	89.18±7.15 fl	5.919	<0.001
	<83fl	52	52%		<83fl	11	11%			
	>101fl	0	0%		>101fl	2	2%			
	Total	100	100%		Total	100	100%			
MCH	29.5±2.5 pg	53	53%	27.72±2.83pg	29.5±2.5pg	91	91%	29.41±1.88 pg	4.974	<0.001
	<27 pg	42	42%		<27 pg	6	6%			
	>32 pg	5	5%		>32 pg	3	3%			
	Total	100	100%		Total	100	100%			
MCHC	33±2.5 %	49	49%	30.75±2.64%	33±2.5 %	83	83%	32.33±2.26%	5.605	<0.001
	<30.5 %	43	43%		<30.5 %	5	5%			
	>35.5 %	8	8%		>35.5 %	12	12%			
	Total	100	100%		Total	100	100%			

*Significance at the level ≤0.05

Table 4: TWBC counts, PLTs counts, Neutrophil counts, and Lymphocyte counts values among Traditional bakers (exposed to wood burning) and controls.

Parameter	Study group traditional bakeries n=100				Control group apparent healthy individuals n=100				t- value	P-value*
	Category	Frequency	percent	Mean ±SD	Category	Frequency	percent	Mean ±SD		
TWBC counts	4-10 ×10^3/l	95	95%	6.77±1.71 ×10^3/l	4-10 ×10^3 /l	97	97%	6.17±1.50 ×10^3/l	2.740	<0.007
	<4×10^3 /l	4	4%		<4×10^3 /l	2	2%			
	>10 ×10^3/l	1	1%		>10 ×10^3 /l	1	1%			
	Total	100	100%		Total	100	100%			
PLT counts	170-450×10^3/l	88	88%	205.29 ±51.49 ×10^3/l	170-450×10^3/l	93	93%	238.11± 59.56 ×10^3/l	4.168	<0.001
	<170 ×10^3/l	12	12%		<170×10^3 /l	5	5%			
	>450 ×10^3 /l	0	0%		>450 ×10^3 /l	2	2%			
	Total	100	100%		Total	100	100%			

Neutrophil counts	40-80%	64	64%	49.59 ±16.43%	40-80%	89	89%	57.36 ±13.93%	3.607	<0.001
	<40%	36	36%		<40%	9	9%			
	>80%	0	0%		>80%	2	2%			
	Total	100	100%		Total	100	100%			
Lymphocyte counts	20-40%	50	50%	36.21 ±13.52%	20-40%	83	83%	29.98±5.70%	4.246	<0.001
	<20%	9	9%		<20%	6	6%			
	>40%	41	41%		>40%	11	11%			
	Total	100	100%		Total	100	100%			

*Significance at the level ≤0.05

Table 5: Red Cell Morphology among traditional bakers.

Red Cell Morphology	Frequency	Percent
Normocytic normochromic	37	37.0
Dimorphic	17	17.0
Microcytic hypochromic	2	2.0
Normal with stomatocyte	34	34.0
Normal with target	6	6.0
Normal with spherocyte	4	4.0
Total	100	100

Discussion:

The exposure to biomass smoke and PAHs induces oxidative stress, represents an imbalance between pro-oxidant and antioxidant systems causing haemolysis which leads to release of free heme, which acts as pro-oxidant and contributes to inflammatory events by increasing the expression of vascular adhesion molecules during haemolysis. However, recent studies have provided evidence of the association between wood-smoke emissions mainly PAH exposure and probable impairments on blood parameters in humans. [23-26] The traditional bakeries workers used wood as a fuel and were exposed to both air pollutants and high temperature. The findings of this study go in line with previous studies done in Ghana in 2019 by Dadzie EK. and his colleagues [28] who indicated low haemoglobin, low MCV, low MCH, low MCHC, and low GRAN which is significantly associated with exposure to wood smoke, and a study done in Pakistan in 2016 by Kamal A, and his colleagues [29] who found low haemoglobin level (Hb) in subjects who had prolonged exposure to combustion of large amounts of fuelwood and coal smoke. Also, it is in agreement with another study done in India by Padhy PK. and his colleagues who in 2009 [30] reported that the children who live in households using traditional biomass fuels for cooking had low Hb levels. But this is not in agreement with regards to neutrophil counts which were found to be increased in the traditional biomass fuel exposed people. In contrast, the study was done on Tandoor occupants in Pakistan in 2014 by Nabi G, et al. [31] stated, high Hb, high HCT, high MCV, High MCHC, High RBCs counts, high lymphocyte counts, and high Platelet counts among Tandoor Occupants who exposed to Wood Smoke when compared to healthy control persons, however the results regarding decreased neutrophil counts, increased lymphocyte counts

and increased TWBCs counts were in agreement with this study. On the other hand, the results concluded by Rabha R. and his colleagues in India during 2018, [32] revealed that platelet counts had a significant positive association with results from emissions released during cooking with fuelwood while haemoglobin had a negative association. The mean of TWBCs counts ($6.77\pm1.71\times10^3$/l vs. $6.17\pm1.50\times10^3$/l; P=0.007), and the mean of lymphocyte counts (36.21±13.52% vs. 29.98±5.70%; P<0.001), were statistically significantly increased in bakers (Table4). Similar results were recorded in previous studies [30, 31, 32] with high white blood cell counts also concluded in a previous study done in Pakistan in 2016 by Kamal A, and his colleagues [29]. Regarding high lymphocyte counts the current study findings agree with the previous study done in Ghana in 2019 by Dadzie EK and his colleagues [28]. The mean of RBCs counts ($4.89\pm0.6\times10^{12}$ vs. $4.90\pm0.42\times10^{12}$;P<0.001), had no statistically significant difference between bakers and control group (Table 3). These results are in contrast with the study done in India by Padhy PK and his colleagues in 2009 [30] who reported low red blood cell (RBC) among wood smoke exposure and study done in Tandoor in 2014 by Nabi G, et al. [31] who stated high RBCs count. The blood morphology of the traditional bakeries workers showed that 37% of the participants RBCs had normocytic normochromic picture, 34% showed normal morphology with presence of stomatocyte cells, 17% showed dimorphic picture, 6% showed normal morphology with presence of target cells, 4% showed normal morphology with presence of spherocyte, and 2% showed microcytic hypochromic picture (Table5). Changes in hematologic parameters in this study are like the findings, in a study conducted by Lal et al. in 2011[33] who measured haematological parameters in rodents, exposed to cow dung smoke for around 12 months. The possible reasons for the similarities and differences in blood parameters in different populations may be due to the length of exposure and the nature of the biomass used. The blood morphology of the traditional bakery workers showed that, 37% of the participants' RBCs had a normocytic normochromic picture, 34% normal with stomatocyte cells, 17% dimorphic picture, 6% normal with target cells, and 4% normal with spherocyte, and 2% showed a microcytic hypochromic picture. (Table 5) This morphological change may be due to long exposure to wood-burning and according to the blood parameters, mainly RBC indices.

Conclusion:

The present study results showed apparently significant effects in approximately all haematological parameters among traditional bakers exposed to wood-burning smoke including the mean of Haemoglobin, Haematocrit, Mean Cell Volume, Mean Cell Haemoglobin, Mean Corpuscular Haemoglobin Concentration, Platelet counts, Neutrophil counts, Total White Blood Cell counts and Lymphocyte counts.

Conflict of Interest: The author declared no conflict of interests.

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