www.directivepublications.org

Journal of
Dentistry and Oral Research

ISSN 2767-4037

Research Article

Assessment Of Oral Health Status Of Lead Acid Battery Workers In Dhaka City Of Bangladesh: A Cross-Sectional Study.

Md. Fazlay Rabby[1], Md. Shihabul Islam[2], Md. Ziaul Islam[3], Baizid Khoorshid Riaz[4], Md. Abdur Rouf[1], Sharmi Saha[1], Tajnuva Mridula[1], Fatima Siam[1], Md. Farib Hasan[1], Arup Kumar Saha[1], Sabiha Kamal[2], Diti Rani Das[5], Pranab Karmaker[2*]

[1]Department of Dental Public Health, City Dental College and Hospital, Dhaka, Bangladesh.
[2]Bangladesh Reference Institute for Chemical Measurements (BRiCM), Dhaka, Bangladesh.
[3]Department of Community Medicine, National Institute of Preventive & Social Medicine, Dhaka, Bangladesh.
[4]Directorate General of Medical Education (DGME), Mohakhali, Dhaka, Bangladesh.
[5]Department of Pathology and Microbiology, Dhaka Dental College, Dhaka, Bangladesh.

Abstract

Background: Oral health issues pose a significant health challenge in many countries all over the world. Exposure to harmful substances such as acid mists found in lead-acid battery factories can adversely affect the tissues in the oral cavity.
Objectives: This study aims to investigate various oral health problems among lead-acid battery workers in Dhaka city of Bangladesh by considering different vital factors.
Materials and Methods: A total 370 lead-acid battery workers from four different battery factories of Dhaka city were included in our present study and divided into two groups (study group and control group) based on acid or acid fumes exposure.
Results: The findings of the current study suggested that a significant number of study participants had been suffering from dental caries (P value: <0.001), dental erosion (P value: <0.001), Sensitive teeth (P value: <0.001), gingivitis (P value: <0.001), oral ulcer (P value: <0.001), stained teeth (P value: 0.022) and mouth odor (P value: 0.048), in relation to their respective controls. Besides, some socio-demographic status including higher weight, obesity, illiteracy, lower family income, working with oral pipe, working >5 years, working >8 hours daily, brushing frequency, using no toothpaste, and some eating or drinking habits including low drinking water, regular intake of fast foods and soft drinks, taking betel leaf and betel nut, Jorda, oral tobacco and smoking were significantly related with oral health problems.
Conclusion: A significant proportion of study participants experienced with various Oro-dental problems due to exposure to lead battery acid fumes.

Keywords: Oral health, Battery workers, Dental erosion, Sensitive teeth, Oral ulcer, Gingivitis.

INTRODUCTION

Optimal oral health is crucial for overall well-being and enhancing quality of life. It involves in free from chronic mouth and facial pain, oral ulcers, gingivitis, sensitive teeth, tooth erosion, oral and throat cancer, oral sores, congenital conditions like cleft lip and palate, periodontal (gum) disease, tooth decay, tooth loss, and other related diseases and disorders [1]. Inadequate oral health during the early stages of life is strongly correlated with adverse oral health conditions that persist from childhood to adulthood and due to this problem individuals are continually susceptible to dental caries throughout their lifetime [2]. Previous researches have demonstrated a connection between oral health and various medical issues like early childhood caries (ECC) can lead to associated health complications, including hypertension and cardiovascular diseases obesity, COVID-19, diabetes mellitus, cancers, [3-8].

Oral diseases remain a public health problem for developed as well as developing countries, especially among the rural population. The World Health Organization (WHO) acknowledges the significant influence that oral health has on an individual's overall well-being, as well as on the collective health of populations. Consequently, WHO has prioritized the enhancement of oral health across all communities [9-10]. Oral health is an essential aspect of overall health, and its

***Corresponding Author:** Dr. Pranab Karmaker.* Bangladesh Reference Institute for Chemical Measurements (BRiCM), Dhaka. **Email:** pranab@bricm.gov.bd.
Received: 29-Apr-2026, Manuscript No. JODOR -5684 **; Editor Assigned:** 30-Apr-2026 **; Reviewed:** 19-May-2026, QC No. JODOR -5684 **; Published:** 22-May-2026. **DOI:** 10.52338/jodor.2026.5684.
Citation: Dr. Pranab Karmaker. Assessment Of Oral Health Status Of Lead Acid Battery Workers In Dhaka City Of Bangladesh: A Cross-Sectional Study. Journal of Dentistry and Oral Research. 2026 May; 17(1). doi: 10.52338/jodor.2026.5684.
Copyright © 2026 **Dr. Pranab Karmaker.** This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

significance is universally acknowledged. Numerous studies have documented the relationship between oral health and various systemic conditions, as well as its impact on quality of life. As evident from previous literature, governments and organizations in many developing countries have placed considerable importance on oral health [11-12].

It is well known that continuous exposure to acidic substances in an industrial setting can significantly harmful for teeth and oral tissues. Inhaling acidic mist in such environments can irritate the nose, mouth, and throat. This exposure can lead to the breakdown of the protective enamel and dentin layers of the teeth, making them vulnerable to acidic decalcification [13]. Moreover, exposure to acid mists may be linked to periodontal disease due to changes in intracellular and extracellular pH, which regulate cell growth and differentiation. These pH alterations can indicate the genotoxic effects and potential carcinogenicity of inorganic acids. Chronic tissue irritation by in organic acids can lead to more frequent infections like exposure to sulfuric acid triggers the immune responses, reducing phagocytic capacity and cytotoxic activity thar increases the chromosomal abnormalities in human lymphocytes [14-16]. Significant results were found that linked between dental erosion and the duration of acid exposure. A survey on 350 male workers at a Norwegian zinc extraction facility and a Japanese copper mine showed different caries patterns among those with dental erosion [17]. Besides, another study was carried out on 223 chromium induced electroplaters in Sao Paulo, Brazil, and the results found that approximately 50% of workers experienced with dental erosion and yellowing within less than a year of exposure [18]. A similar result was found in a case report in Jordan that patient had 20 years of working period in the chromium exposed occupation and this duration is high enough to result dental erosion [19].

The battery factories are the largest consumers of lead that utilizing approximately 80% of the global lead production. Around half of this lead production is issued to manufacturing lead-acid batteries. Additionally, 20% of lead production is used in various metal applications, such as cable sheathing, solder, ammunition, alloys, weights, ballast, and low-melting alloys [20, 21]. Lead compounds are utilized in a variety of applications including painting, stabilizing in glassware, ceramics, and plastics, manufacturing television tubes, and as antiknock additives in gasoline [22-25]. The most common forms of lead compounds are lead oxide (PbO) and lead tetra oxide (Pb3O4), which are used in the production of electric battery plates. However, these compounds are significant environmental and occupational pollutants due to their acidic nature [26-27]. Adults are predominantly exposed to lead in occupational place by means of inhaling lead particles and consuming lead contaminated water and food. Exposure to environmental lead is clearly a major public health hazard of global dimensions. However, because of rapid industrialization and the persistence of lead in the environment, exposure is likely to remain a significant public health problem in most developing countries for many years [28-30].

A comparative study among battery workers revealed a significant association between exposure to acid fumes in battery factories and dental erosion, as well as deteriorated oral health. Many factory workers involved in lead-acid battery production face risks to their oral health. However, information on oral health issues among lead-acid battery workers in Bangladesh is scarce. This study aims to investigate oral health problems such as dentition status, dental erosion, dental caries, attachment loss, periodontitis, tooth sensitivity, oral ulcers, loss of sensation, and swelling among these workers by considering various factors, including dental status, job-related activities, personal habits, dietary habits, and socio-demographic characteristics. The findings will aid in developing targeted measures to prevent and manage major oral health problems among lead-acid battery workers in Bangladesh.

MATERIALS AND METHODS

Study design and study place

This cross-sectional study was conducted to assess oral health status of lead acid battery workers. The study was conducted from January to December 2022. It started with protocol development and completed with final report submission. A work schedule was prepared including all the tasks in a sequence. The first four months were applied for literature review and strategy finalization. The subsequent months were passed for questionnaire development, pretesting, data collection, compilation and analysis. The study areas were selected purposively for availability of lead acid battery workers, easy communication and well cooperation from the workers. The study was conducted in four workshops of Dhaka city including Mohakhali, Saidabad, Gabtoli, Dholaikhal. The workers expressed their interest to participate voluntarily in this study.

Selection of study participants

There are about 5000 lead acid battery factory workers in Dhaka city. The sample size was calculated by using sample size calculator [31] with 95% confidence level and 5% confidence interval. The sample size for the current study was calculated as 357, though the sample size was calculated as 357, we enrolled total 370 workers randomly for our present study. There were two types of workers in lead acid battery factories: (i) the workers who exposed to lead acid fumes (working in forming and charging department), and (ii) the workers who are not exposed to lead acid fumes (working in pasting, grid casting and packaging department). The first study group comprising 185 workers was considered as

experimental group (cases) and the latter one consisting of 185 workers was regarded as control group (controls).

Selection criteria

The study groups were fully briefed on the purpose of our current study and their consent was obtained prior to their participation to avoid any inconvenience and ensure their complete cooperation. The lead acid battery factory workers of all age groups who were present at the time of the study and willing to participate were included in our current study. The workers who were not willing to participate were excluded from this study. The examiner was well trained and calibrated to ensure consistent diagnosis and preventing any variability among the study subjects.

Data collection

A detailed schedule was prepared well in advance for the survey study and the investigator visited the study area within the prescheduled timeframe during the study period until the required sample size was obtained. A sufficient number of sterile instruments were used for the examinations during the study including plain mouth mirrors, explorers, tweezers, kidney trays, containers, Betadine™, saline, gauze, cotton with a cotton holder, disposable gloves, mouth masks, and data recording proforma. Data were collected by face-to-face interview, clinical oral examination with oral health index. The interview was conducted privately as far as possible and before preceding the data collection, the detail of the study was explained to each eligible workers and informed written consents were obtained from the workers. Interview and oral checkup were taken in a quiet place; no other person was allowed to influence the replying of the workers. It took on average 30 minutes to complete the interview of a single worker. Data were collected from 10 am to 4 pm. On an average, 10 workers were interviewed daily. Information was recorded about the department within the battery factory, job duration, exposure to various working conditions, and oral symptoms. Additionally, details such as name, age, sex, location, dietary habits, deleterious habits, and oral hygiene practices were documented. All the data were recorded by maintaining the World Health Organization 2013 (WHO-2013) proforma with slight modification.

Ethical consideration

Initially ethical clearance was obtained from the Institutional Review Board (IRB) of NIPSOM. The participants were briefed properly and motivated to participate in the study. The study participants were informed about the objectives, purposes of the study and informed consent would be taken from each participant. No intervention or any invasive procedures were applied in this study. The participants were interviewed separately and confidentially would be maintained strictly.

Statistical analysis

The raw data was obtained in a tabulated form using Microsoft Excel spreadsheet software. Data analysis was performed using the Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA) version 20.0. The Chi-square test was used to compare categorical variables for proportions, the Mann–Whitney U-test was employed to compare quantitative ordinal variables, and the independent samples t-test was utilized to compare quantitative continuous variables. Descriptive statistical analysis included mean, median, mode, SD. Inferential statistics included chi square test to find out any significant relationship between two qualitative variables. The P values less than 0.05 were considered statistically significant.

RESULTS

Socio-demographic status of study participants

In our current study, a total 370 Bangladeshi individuals were participated, of which 185 (50%) individuals were as experimental group where 185 (50%) were considered as control. The major portion of the both experimental group (69.7%) and control group (67.6%) were less than 30 years old. The comparison data of case and control group suggested that the experimental participants with lower weight (P value: 0.028), higher BMI (P value: 0.006), no literacy (P value: 0.001), lower income (P value: 0.003) had been significantly more suffering from oral health problems in relation to their corresponding control. Moreover, the case individuals who work with oral pipe (P value: <0.001), work more than 5 years (P value: <0.001) and work more than 8 hours per day (P value: 0.001) were significantly more affected with oral problems in comparison to their respective control group. Furthermore, the participants who brush their teeth once per day (P value: 0.003) and without toothpaste (P value: <0.001) had been significantly more suffering from oral problem rather than their respective control. But there no significant difference was found between experimental group and control group in case of body height, family type, sound sleep, exercise and use tooth brush (**Figure 1 and Table S1**).

Figure 1. The socio-demographic status of overall lead acid battery workers (Cases and Controls).

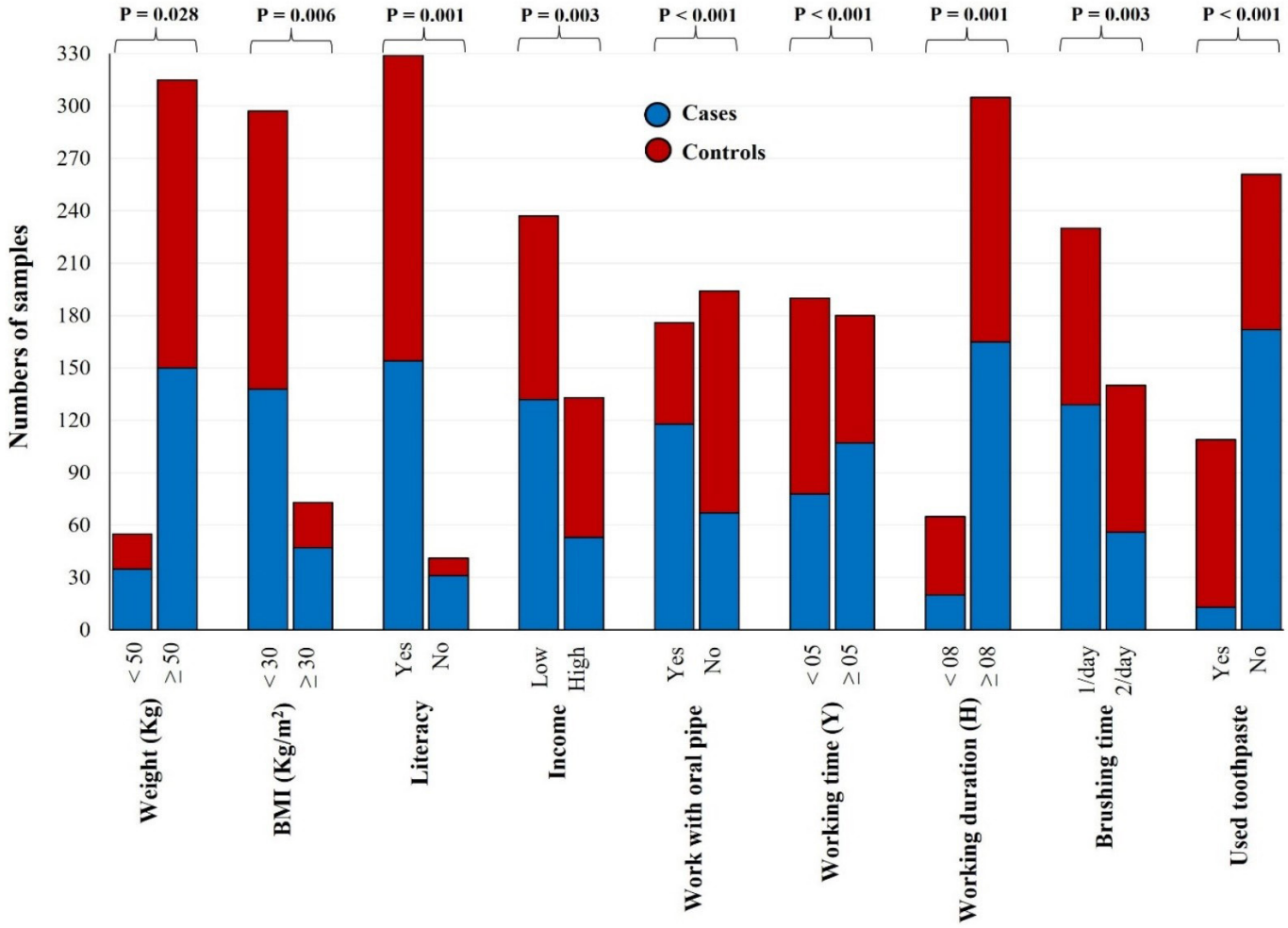


Table 1. The subgroup analysis for experimental participants (only case group) based on different Oro-dental problems.

Variables	Types	Dental caries, n (%)			Dental erosion, n (%)			Sensitive teeth, n (%)			Gingivitis, n (%)			Oral ulcer, n (%)		
		Yes	No	P value	Yes	No	P value	Yes	No	P value	Yes	No	P value	Yes	No	P value
Obesity	Yes	31 (17)	16 (08)	0.222	36 (19)	11 (06)	0.003	35 (19)	12 (06)	0.005	25 (14)	22 (12)	0.691	27 (15)	20 (11)	0.712
	No	77 (42)	61 (33)		71 (39)	67 (36)		70 (38)	68 (37)		78 (42)	60 (32)		75 (40)	63 (34)	
Educational status	Yes	88 (48)	66 (35)	0.447	84 (46)	70 (38)	0.043	81 (44)	73 (39)	0.011	91 (49)	63 (35)	0.037	77 (42)	77 (42)	0.002
	No	20 (11)	11 (06)		23 (12)	08 (04)		24 (13)	07 (04)		12 (06)	19 (10)		25 (13)	06 (03)	
High/ Medium income	Yes	12 (06)	41 (22)	<0.001	24 (13)	29 (16)	0.028	41 (22)	12 (06)	<0.001	31 (17)	22 (12)	0.625	73 (39)	59 (32)	0.942
	No	96 (53)	36 (19)		83 (45)	49 (26)		64 (35)	68 (37)		72 (39)	60 (32)		29 (16)	24 (13)	
Work with oral pipe	Yes	76 (41)	42 (23)	0.027	54 (29)	64 (35)	<0.001	76 (41)	42 (23)	0.005	51 (28)	67 (36)	<0.001	77 (41)	41 (22)	<0.001
	No	32 (17)	35 (19)		53 (28)	14 (08)		29 (16)	38 (20)		52 (28)	15 (08)		25 (14)	42 (23)	
Working more than 5 years	Yes	84 (45)	23 (12)	<0.001	72 (39)	35 (19)	0.002	78 (41)	29 (16)	<0.001	67 (36)	40 (22)	0.026	89 (48)	18 (10)	<0.001
	No	24 (13)	54 (30)		35 (19)	43 (23)		27 (15)	51 (28)		36 (19)	42 (23)		13 (07)	65 (35)	
Working more than 8 hours/ day	Yes	95 (51)	70 (38)	0.525	96 (52)	69 (37)	0.786	99 (54)	66 (36)	0.011	89 (48)	76 (41)	0.172	94 (52)	71 (38)	0.150
	No	13 (07)	07 (04)		11 (06)	09 (05)		06 (03)	14 (07)		14 (08)	06 (03)		08 (04)	12 (06)	
Brushing twice per day	Yes	20 (11)	36 (19)	<0.001	15 (08)	41 (22)	<0.001	11 (06)	45 (24)	<0.001	50 (27)	06 (03)	<0.001	38 (21)	18 (10)	0.022
	No	88 (48)	41 (22)		92 (50)	37 (20)		94 (51)	35 (19)		53 (29)	76 (41)		64 (34)	65 (35)	
Brushing with toothpaste	Yes	02 (01)	11 (06)	0.001	03 (02)	10 (05)	0.008	02 (01)	11 (06)	0.002	02 (01)	11 (06)	0.002	03 (02)	10 (05)	0.016
	No	106 (57)	66 (36)		104 (56)	68 (37)		103 (56)	69 (37)		101 (55)	71 (38)		99 (54)	73 (39)	
Intake sugar rich foods	Yes	47 (25)	23 (12)	0.059	56 (30)	70 (38)	<0.001	61 (33)	65 (35)	0.001	68 (37)	58 (31)	0.494	65 (35)	61 (33)	0.156
	No	61 (33)	54 (30)		51 (28)	08 (04)		44 (24)	15 (08)		35 (19)	24 (13)		37 (20)	22 (12)	

Intake water 8 glass/day	Yes	45 (24)	16 (09)	0.003	36 (19)	25 (14)	0.820	51 (28)	10 (05)	<0.001	14 (08)	47 (25)	<0.001	11 (06)	50 (27)	<0.001
	No	63 (34)	61 (33)		71 (38)	53 (29)		54 (29)	70 (38)		89 (48)	35 (19)		91 (49)	33 (18)	
Intake fast food/ soft drinks	Yes	88 (48)	60 (32)	0.551	96 (52)	52 (28)	<0.001	91 (49)	57 (31)	0.009	79 (43)	69 (37)	0.208	87 (47)	61 (33)	0.046
	No	20 (11)	17 (09)		11 (06)	26 (14)		14 (08)	23 (12)		24 (13)	13 (07)		15 (08)	22 (12)	
Intake betel leaf/betel nut	Yes	77 (42)	22 (12)	<0.001	82 (44)	17 (09)	<0.001	88 (48)	11 (06)	<0.001	91 (49)	08 (04)	<0.001	93 (50)	06 (03)	<0.001
	No	31 (16)	55 (30)		25 (14)	61 (33)		17 (09)	69 (37)		12 (06)	74 (41)		09 (05)	77 (42)	
Intake jorda	Yes	62 (34)	16 (09)	<0.001	30 (16)	48 (26)	<0.001	58 (31)	20 (11)	<0.001	65 (35)	13 (07)	<0.001	68 (38)	10 (05)	<0.001
	No	46 (24)	61 (33)		77 (42)	30 (16)		47 (25)	60 (33)		38 (21)	69 (37)		34 (18)	73 (39)	
Intake oral tobacco	Yes	64 (35)	43 (23)	0.042	74 (40)	13 (07)	<0.001	68 (37)	19 (10)	<0.001	68 (37)	19 (10)	<0.001	82 (44)	05 (03)	<0.001
	No	44 (24)	34 (18)		33 (18)	65 (35)		37 (20)	61 (33)		35 (19)	63 (34)		20 (11)	78 (42)	
Smoking	Yes	99 (54)	61 (33)	0.015	97 (53)	63 (34)	0.052	98 (53)	62 (34)	0.002	99 (54)	61 (33)	<0.001	99 (54)	61 (32)	<0.001
	No	09 (05)	16 (08)		10 (05)	15 (08)		07 (04)	18 (09)		04 (02)	21 (11)		03 (02)	22 (12)	

Food habits of study participants

In our current investigation, the food habit of the study participants was analyzed and a significant proportion of experimental participants (who were suffering from oral health problem) were found to intake less than 8 glass of water per day (P value: 0.004), to eat fast food regularly (P value: 0.012), to take soft drinks in regular basis (P value: 0.017) rather than their respective controls. Moreover, a significant number experimental participants with oral health problem were detected to consume betel leaf (P value: 0.009) and betel nut (P value: 0.009), to take jorda (P value: 0.001), having smoking habit (P value: <0.001), and to take oral tobacco (P value: 0.002) in comparison to their corresponding controls. But no significant number of experimental participants with oral health problem were found in case of taking carbohydrate, protein, fat, vegetables, fruits, supplemental vitamins and minerals, and drinking tea or coffee in relation to their respective controls (**Figure 2 and Table S2**).

Figure 2. The food and drinking habits of overall study participants (Cases and Controls).

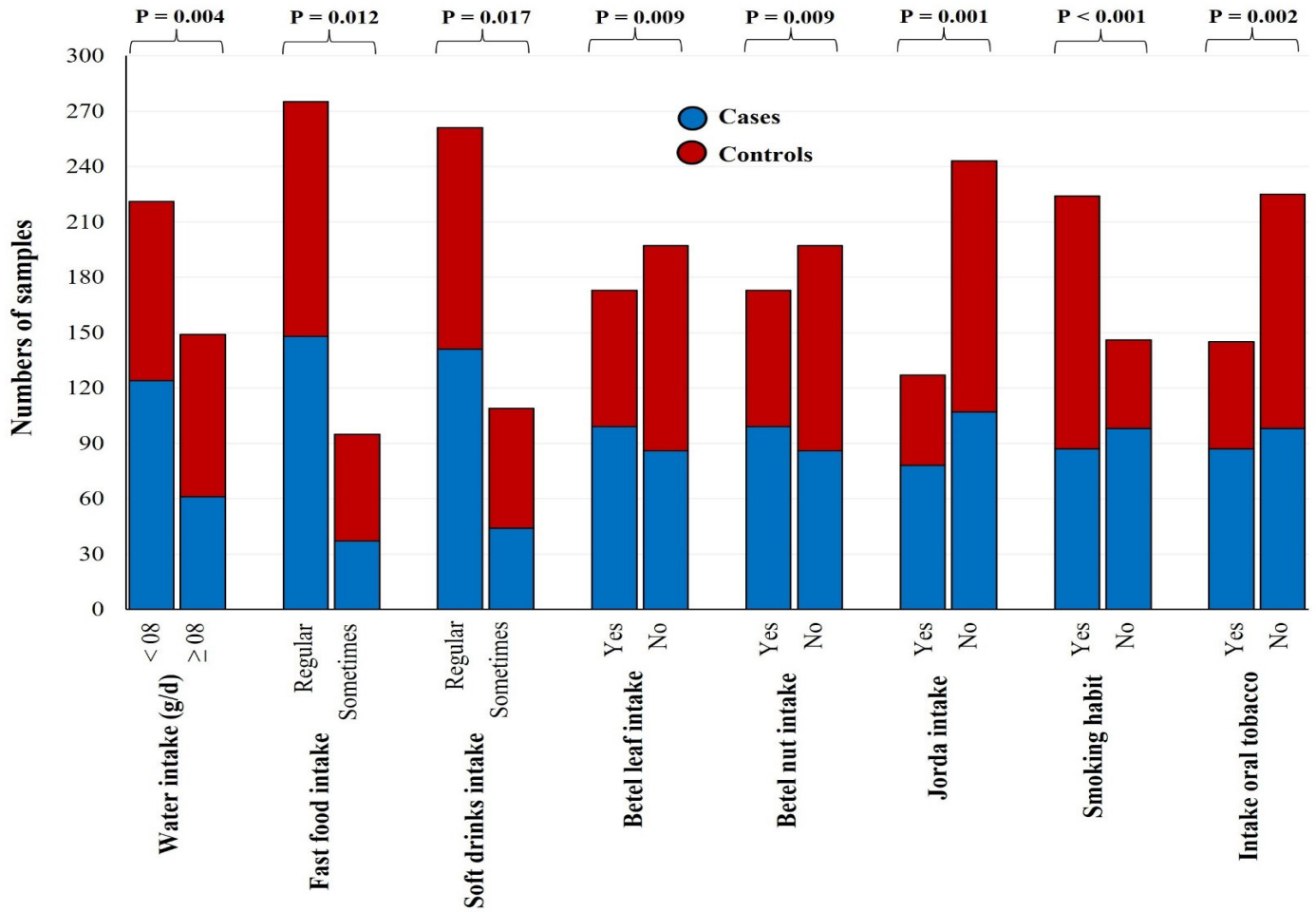


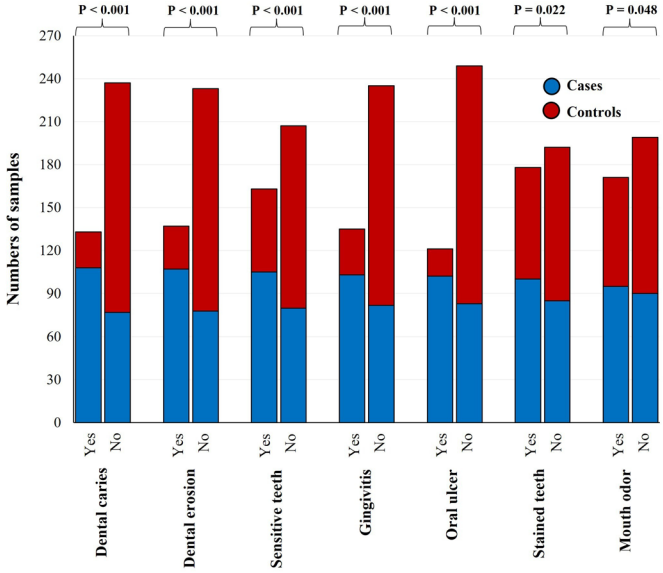
Table 2. Regression analysis of study participants (Case vs. Control) using several variables.

Variables	Categories	Cases (%)	Controls (%)	Odds ratio (95% CI)	P values
Weight (Kg)	< 50	035 (18.9)	020 (10.8)	1.93 (1.06 – 3.48)	0.030
	≥ 50	150 (81.1)	165 (89.2)		
BMI (Kg/m2)	≥ 30	047 (25.4)	026 (14.1)	2.08 (1.23 – 3.54)	0.007
	< 30	138 (74.6)	159 (85.9)		
Literacy	No	031 (16.8)	010 (05.4)	3.52 (1.67 – 7.42)	0.001
	Yes	154 (83.2)	175 (94.6)		
Income	Low	132 (71.4)	105 (56.8)	1.90 (1.23 – 2.92)	0.004
	Middle	053 (28.6)	080 (43.2)		
Work with oral pipe	Yes	118 (63.8)	058 (31.4)	3.86 (2.50 – 5.94)	< 0.001
	No	067 (36.2)	127 (68.6)		
Working time (Years)	≥ 5	107 (57.8)	073 (39.5)	2.10 (1.39 – 3.19)	< 0.001
	< 5	078 (42.2)	112 (60.5)		
Working duration (h)	≥ 8	165 (89.2)	140 (75.7)	2.65 (1.50 – 4.70)	0.001
	< 8	020 (10.8)	045 (24.3)		
Brushing time	Once/day	129 (69.7)	101 (54.6)	1.92 (1.25 – 2.94)	0.003
	Twice/day	056 (30.3)	084 (45.4)		
Used toothpaste	No	172 (93.0)	089 (48.1)	14.3 (7.58 – 26.9)	< 0.001
	Yes	013 (07.0)	096 (51.9)		
Water intake (Glaas/D)	< 8	124 (67.0)	097 (52.4)	1.84 (1.21 – 2.81)	0.004
	≥ 8	061 (33.0)	088 (47.6)		
Fast food	Regular	148 (80.0)	127 (68.6)	1.83 (1.14 – 2.94)	0.013
	Sometimes	037 (20.0)	058 (31.4)		
Soft drinks	Regular	141 (76.2)	120 (64.9)	1.74 (1.10 – 2.73)	0.017
	Sometimes	044 (23.8)	065 (35.1)		
Betel leaf	Yes	099 (53.5)	074 (40.0)	1.73 (1.14 – 2.61)	0.009
	No	086 (46.5)	111 (60.0)		
Betel nut	Yes	099 (53.5)	074 (40.0)	1.73 (1.14 – 2.61)	0.009
	No	086 (46.5)	111 (60.0)		
Jorda	Yes	078 (42.2)	049 (26.5)	2.02 (1.31 – 3.14)	0.002
	No	107 (57.8)	136 (73.5)		
Smoking	Yes	098 (53.0)	048 (25.9)	3.22 (2.08 – 4.98)	< 0.001
	No	087 (47.0)	137 (74.1)		
Oral tobacco	Yes	087 (47.0)	058 (31.4)	1.94 (1.27 – 2.97)	0.002
	No	098 (53.0)	127 (68.6)		
Dental caries	Yes	108 (58.4)	025 (13.5)	8.98 (5.37 – 14.9)	< 0.001
	No	077 (41.6)	160 (86.5)		
Dental erosion	Yes	107 (57.8)	030 (16.2)	7.09 (4.35 – 11.5)	< 0.001
	No	078 (42.2)	155 (83.8)		
Sensitive teeth	Yes	105 (56.8)	058 (31.4)	2.87 (1.88 – 4.40)	< 0.001
	No	080 (43.2)	127 (68.6)		
Gingivitis	Yes	103 (55.7)	032 (17.3)	6.01 (3.72 – 9.69)	< 0.001
	No	082 (44.3)	153 (82.7)		
Oral ulcer	Yes	102 (55.1)	019 (10.3)	10.7 (6.16 – 18.7)	< 0.001
	No	083 (44.9)	166 (89.7)		
Stained teeth	Yes	100 (54.1)	078 (42.2)	1.61 (1.07 – 2.43)	0.022
	No	085 (45.9)	107 (57.8)		
Mouth odor	Yes	095 (51.4)	076 (41.1)	1.51 (1.00 – 2.28)	0.048
	No	090 (48.6)	109 (58.9)		

Oro-dental problems of study participants

The analysis of overall distribution of study participants based on ore-dental problems revealed that a significant number cases were suffering from dental caries (P value: <0.001), dental erosion (P value: <0.001), sensitive teeth (P value: <0.001), gingivitis (P value: <0.001), oral ulcer (P value: <0.001), stained teeth (P value: 0.022), and mouth odor (P value: 0.048), compared to their corresponding controls. However, no significant differences were observed between experimental group and control group regarding of dry mouth, toothache, root infections, enamel erosion, periodontics, broken teeth, tooth cavity, Hyperdontia and cracked tooth when compared to their respective controls (**Figure 3 and Table S3**).

Figure 3. The distribution of overall study participants (Cases and Controls) by Oro-dental problems.



Subgroup analysis of experimental participants by dental caries

The subgroup analysis by dental caries suggested that a significant proportion of experimental participants experiencing with dental caries whose family income is comparatively lower (53%, P value: <0.001), working with oral pipe (41%, P value: 0.027), working in the workshop more than 5 years (45%, P value: <0.001), not brushing twice per day (48%, P value: <0.001), brushing without toothpaste (57%, P value: 0.001), drinking water less than 8 glass per day (34%, P value: 0.003), intaking betel leaf and betel nut (42%, P value: <0.001), taking Jorda (34%, P value: <0.001), taking tobacco orally (35%, P value: 0.042) and having smoking habit (54%, P value: 0.015). But no significant difference was found among experimental participants with or without dental caries in case of obesity, educational status, working hour, intake sugar rich food, and intake fast food or soft drinks **Table 1**.

Subgroup analysis of experimental participants by dental erosion

The results of subgroup analysis by dental erosion revealed that obesity (P value: 0.003) and educational status (P value: 0.043) is not significantly associated with dental erosion where low income (P value: 0.028), working with oral pipe (P value: <0.001), and working more than 5 years (P value: 0.002) were significantly related with dental erosion. Additionally, a significant number of experimental participants have been suffering from dental erosion who did not brushing twice daily (50%, P value: <0.001), brushing without toothpaste (56%, P value: 0.008), consuming sugar rich foods (30%, P value: <0.001), fast foods or soft drinks (52%, P value: <0.001), and having habit of chewing betel leaf or betel nut (44%, P value:<0.001), Jorda (42%, P value: <0.001), oral tobacco (40%, P value: <0.001). But no significant portion of the study participants were experiencing with dental erosion regarding by daily working time, intaking water glass per day and having habit of smoking (**Table 1**).

Subgroup analysis of experimental participants by sensitive teeth

The subgroup analysis by sensitive teeth demonstrated that a significant number of experimental participants have sensitive teeth who is not obese (P value: 0.005), having educational status (P value: 0.011), belonging to lower income family (P value: <0.001), working with oral pipe (P value: 0.005), working at factories in more than 5 years (P value: <0.001), working more than 8 hours daily (P value: 0.011), not brushing twice daily (P value: <0.001), brushing without toothpaste (P value: 0.002), consume sugar rich foods (P value: 0.001), drinking less than 8 glass of water daily (P value: <0.001), taking fast foods or soft drinks (P value: 0.009), having habit of using betel leaf or betel nut (P value: <0.001), taking Jorda (P value:

<0.001) and oral tobacco (P value: <0.001) and smoking (P value: 0.002) (**Table 1**).

Subgroup analysis of experimental participants by gingivitis

The results of the subgroup analysis based on gingivitis indicated that participants with higher educational status were significantly more likely to experience gingivitis (49%, P value: 0.037). Furthermore, a significant proportion of experimental participants have been facing with gingivitis who are working from more than 5 years (36%, P value: 0.026), brushing without toothpaste (55%, P value: 0.002), not drinking more than 8 glass of water (48%, P value: <0.001), taking betel nut or betel leaf (49%, P value: <0.001), taking oral tobacco (37%, P value: <0.001), and having habit of smoking (54%, P value: <0.001). However, a significant number of participants have not suffered from gingivitis who are working with oral pipe (36%, P value: <0.001), not brushing twice per day (41%, P value: <0.001), not taking Jorda (37%, <0.001). But no significant number of participants were experiencing with gingivitis regarding of obesity, status of family income, daily working time, taking sugar rich foods and intaking fast foods or soft drinks (**Table 1**).

Subgroup analysis of experimental participants by oral ulcer

The subgroup analysis of oral ulcers showed that participants with higher educational status were significantly less likely to suffer from oral ulcers (77%, P value: 0.002). Besides, a significant percentage of experimental participants were experiencing with oral ulcer who are working with oral pipe (41%, P value: <0.001), working at workshop form more than 5 years (48%, P value: <0.001), brushing without toothpaste (54%, P value: 0.016), not drinking more than 8 glass of water (49%, P value: <0.001), taking fast foods and soft drinks (47%, P value: 0.046), taking betel leaf or betel nut (50%, P value: <0.001), having habit of using oral tobacco (44%, P value: <0.001) and smoking (54%, P value: <0.001). But participants who brushed twice per day have been not suffering from oral ulcer significantly (35%, P value: 0.022) where comparatively larger proportion of participants were facing with oral ulcer who did not take Jorda (39%, P value: <0.001). However, no significant number of participants were experiencing with oral ulcer in case of obesity, family income, working time per day, and intake sugar rich foods (**Table 1**).

Regression analysis of the study variables

The overall regression analysis of the study variables suggested that anthropometric characteristics including weight (< 50 Kg) [OR: 1.93, 95% CI (1.06-3.48), P value: 0.030]; Body mass index (≥ 30 Kg/m2) [OR: 2.08, 95% CI (1.23-3.54), P value: 0.007]; illiteracy [OR: 3.52, 95% CI (1.67-7.42), P value: 0.001] and low income [OR: 1.90, 95% CI (1.23-2.92), P value: 0.004] showed significant correlations with overall oral health problems (Table 2). Moreover, the results of this analysis revealed that the participants working with oral pipe [OR: 3.86, 95% CI (2.50-5.94), P value: <0.001]; working more than 5 years [OR: 2.10, 95% CI (1.39-3.19), P value: <0.001]; working more than 8 hours daily [OR: 2.65, 95% CI (1.50-4.70), P value: 0.001]; brushing once per day [OR: 1.92, 95% CI (1.25-2.94), P value: 0.003]; and brushing without toothpaste [OR: 14.3, 95% CI (7.58-26.9), P value: <0.001] have significant correlation with overall Oro-dental complications (**Table 2**).

Furthermore, the analysis of eating habit demonstrated that the participants who are drinking 8 glass of water per day [OR: 1.84, 95% CI (1.21-2.81), P value: 0.004]; eating fast foods regularly [OR: 1.83, 95% CI (1.14-2.94), P value: 0.013]; and taking soft drinks [OR: 1.74, 95% CI (1.10-2.73), P value: 0.017]; were significantly more affected by oral health problems in comparison to their respective controls (Table 2). Additionally, the habit of taking betel leaf [OR: 1.73, 95% CI (1.14-2.61), P value: 0.009]; and betel nut [OR: 1.73, 95% CI (1.14-2.61), P value: 0.009]; using Jorda [OR: 2.02, 95% CI (1.31-3.14), P value: 0.002]; having oral tobacco [OR: 1.94, 95% CI (1.27-2.97), P value: 0.002]; and smoking [OR: 3.22, 95% CI (2.08-4.98), P value: <0.001]; have significant relationship with overall oral health problems (**Table 2**).

Besides, the regression analysis on Oro-dental problems showed that a significant proportion of experimental participants were affected by dental caries [OR: 8.98, 95% CI (5.37-14.9), P value: <0.001]; dental erosion [OR: 7.09, 95% CI (4.35-11.5), P value: <0.001]; sensitive teeth [OR: 2.87, 95% CI (1.88-4.40), P value: <0.001]; gingivitis [OR: 6.01, 95% CI (3.72-9.69), P value: <0.001]; oral ulcer [OR: 10.7, 95% CI (6.16-18.7), P value: <0.001]; stained teeth [OR: 1.61, 95% CI (1.07-2.43), P value: 0.022]; and mouth odor [OR: 1.51, 95% CI (1.00-2.88), P value: 0.048] in relation to their corresponding control (Table 2).

DISCUSSION

Generally, a large proportion of acid mists are produced from dilute sulfuric acid and open container of lead acid battery factories that are significantly corelated with human health issue especially oral health [32]. This acid mists may affect the oral health either by direct exposure or by systematic exposure and these processes of exposure for long time can cause irritation to soft oral tissues, which can lead to alterations in the oral health including lesions on the oral mucosa, periodontal issues, gingivitis oral bleeding and so on [33-35]. The current study was carried out to evaluate the oral health status in led battery factory workers and investigated the prevalence and types of oral health problems among workers who exposed to acid mists in Dhaka city, Bangladesh. In our present study, 185 battery workers were participated

as study group (case group) who exposed to lead acid mists where age matched 185 workers were participated as control group who did not expose to acid fumes. The study group had the highest percentage of participants in the cases of those who were under 30 years old (69.7%), below 1.5 meters tall (53.0%), living in nuclear families (90.8%), living with low family incomes (71.4%), living in semi-built homes (73.5%), working over 8 hours (89.2%), doing no exercise (80.5%), not getting enough sleep (76.8%), brushing once a day (69.7%) and using no toothpaste (93.0%) (Table S1). Conversely, the majority of participants in the control group were those who weighed over 50 kg (89.2%), had a BMI of less than 30 kg/m2 (85.9%), were the most literate (94.6%), did not use an oral pipe (68.6%), had been employed for less than five years (60.5%), and used a toothbrush (96.2%) (Table S1). But a previous study carried out by Khurana et al. showed about 90.0% of study participants had experiences with more than 5 years which is completely opposite to our present study [13, 36]. Additionally, the experimental group included the greatest percentage of participants when it came to those who consumed fat (75.1%) and carbohydrates (72.4%) more frequently than twice a day, fruits irregularly (83.2%), less than eight glasses of water daily, fast food (80.0%), and soft drinks (76.2%) on a regular basis (Table S2). However, the control group had the highest proportion of participants who took protein less than twice a day (64.9%), ate vegetables on a regular basis (70.3%), did not consume minerals (90.3%) or vitamins (88.1%), drank tea or coffee on a regular basis (78.9%), did not consume betel leaf (60.0%), betel nut (60.0%), Jorda (73.5%), oral tobacco (68.6%), or smoked (74.1%) (Table S2). Dental erosion is the oral health issue that is characterized by a loss of dental hard tissue by different chemicals including acid mists [37]. A number of earlier studies conducted by Khurana et al. (2014) [13], Raj et al. (2016) [36], Kundu et al. (2017) [38], and others found that the persons who exposed to acid mists in battery factories experienced with considerable dental erosion. A similar finding was assessed in our current study, which revealed that the dental erosion of study group was significantly higher in comparison to their corresponding control group (P value: <0.001) (Figure 3 and Table S3). In our present investigation, as seen by Figure 3 and Table S3, a higher prevalence of gingivitis among experimental participants was found in comparison to their corresponding controls (P value: <0.001). This finding was consistent with research conducted by Khurana et al. (2014) [13], Amin et al. (2001) [19], and Kundu et al. (2017) [38]. Besides, the comparison of mouth odor in both the groups revealed a statistically significant difference (P value: 0.048) which was similar to the results from the studies conducted by Khurana et al. (2014) [13], and Raj et al. (2016) [36]. Moreover, oral ulcer is one of the most prevalence oral health problems among battery factory workers. Several scientists studied the oral health of workers in battery factories and Raj et al. (2016) [36] showed a significant number of study participants were suffering from oral ulcer and this result was consistent to our current findings (P value: <0.001). Additionally, the comparison of sensitive teeth in both study and control groups demonstrated that the study participants had comparatively more sensitive teeth (P value: <0.001) in relation to their respective controls which was similar with the findings of Khurana et al. (2014) [13].

On the other hand, a different number of studies was conducted previously on oral health issues by Khurana et al. (2014) [13], and Raj et al. (2016) [36] and reported that a significant number of study participants were observed to have dry mouth but no significant (P value: 0.600) difference was detected between the experimental group and control group in our present study (Table S3). Moreover, an earlier study carried out by Kundu et al. (2017) [38] revealed that a considerable proportion of study participants had enamel erosion and periodontics when compared to their respective controls. These results conflicted with the findings of our present investigation as no significant number of study participants was evaluated who had enamel erosion (P value: 0.122) and periodontics (P value: 0.234) (Table S3). Furthermore, no significant number of participants with toothache (P value: 0.521) was observed among study groups in comparison to their matching controls and our results were supported by the previous researches conducted by Khurana et al. (2014) [13], and Raj et al. (2016) [36].

Obesity is one of the most important risk factors for the development of many human diseases, including oral and dental disorders. Previous researches conducted by Suvan et al. (2013) [39] and Keller et al. (2015) [40] demonstrated a substantial correlation between obesity and a number of oral health conditions, like dental caries, periodontal disease, xerostomia, dental erosion, and dentinal hypersensitivity. In the present study, we found a significant relationship between obesity and sensitive teeth (P value: 0.005) as well as dental erosion (P value: 0.003) (Table 2). Moreover, in our current study, low educational status was significantly associated with dental erosion (P value: 0.043), sensitive teeth (P value: 0.011), gingivitis (P value: 0.037), and oral ulcer (P value: 0.002); low family income was considerably related with dental caries (P value: <0.001), dental erosion (P value: 0.028), and sensitive teeth (P value: <0.001), and smoking habit had a significant association with dental caries (P value: 0.015), sensitive teeth (P value: 0.002), gingivitis (P value: <0.001), and oral ulcer (P value: <0.001) (Table 2) and these findings are agreed by Moghaddam et al. (2020) [41], and Baniasadi et al. (2021) [42]. Additionally, the present experiment showed that the participants who had been working for more than 5 years, worked over 8 hours per day, did not brush twice per day, did not use toothpaste, took betel nut or betel leaf, Jorda and oral tobacco were significantly suffering from dental

caries, dental erosion, sensitive teeth, gingivitis and oral ulcer (Table 2). These results were supported by different previous researches including Khurana et al. (2014) [13], Raj et al. (2016) [36], Yang et al. (2024) [43], Gunjal et al. [44], Gajendra et al. [45], Calzada et al. [46], and so on. Besides, food and drinking habit are very much crucial for the development of different oral health problems. A several studies carried out by Tenelanda et al. (2020) [47], Butera et al. (2022) [48], Elamin et al. (2018) [49], and Paszynska et al. (2022) [50] revealed that eating habit and drinking habit had significant relationship with increased risk of developing different oral health issues including dental caries, dental erosion, periodontics, dry mouth, toothache, sensitive teeth, oral cancer etc. These similar results were found in our present investigation as intake sugar rich food was significantly related with dental erosion, and sensitive teeth; drinking less than 8 glass of water daily was significantly associated with dental caries, sensitive teeth, gingivitis and oral ulcer; and intake fast food or soft drinks was significantly correlated with dental erosion, sensitive teeth, and oral ulcer.

CONCLUSION

In summary, the results of this study suggested that the study participants who exposed to acid fumes in battery factories were significantly more affected by oral health problems including dental caries, dental erosion, sensitive teeth, gingivitis, oral ulcer, stained teeth and mouth odor compared to the participants who did not expose to acid fumes. Moreover, some anthropometrics characteristics like weight (<50Kg), BMI (≥30 Kg/m2), illiteracy, and low family income; some working habits such as using oral pipe, working more than 5 years, working more than 8 hours daily, brushing frequency, using toothpaste during bruising; some eating or drinking habit including low drinking water, regular intake of fast foods and soft drinks, taking betel leaf and betel nut, jorda, oral tobacco and smoking were significantly related with Oro-dental problem of experimental groups. But some limitations were arisen during conducting our present study including small sample size. So, large scale should be conducted to find out real picture of the oral health status of the lead acid battery workers in Dhaka city of Bangladesh.

Recommendation

The main objective of this study was to assess oral health status of lead acid battery workers. This study revealed that lead acid battery workers do have some sort of Oro-dental health problems such as dental caries, dental erosion, oral ulcer, sensitive teeth, stained teeth, gingivitis, periodontitis and so on. On the basis of this study findings, to recommend following measures for the lead acid battery workers: firstly, to improve oral health status of the workers, special attention should be given by adopting effective measures like health education, awareness program, work health facility. Secondly, to prevent dental caries comprehensive measures including fluoride containing tooth paste, mouth wash and brushing of teeth twice daily and need proper treatment and dental flossing. Thirdly, to control Oro-dental health problems of the workers, special preventive measure like regular mouth gargling, scaling, filling etc. should be given. Fourthly, to prevent dental erosion of the workers, regular oral checkup should be arranged and according measures should be taken. Fifthly, to prevent oral ulcer specific initiation like consumption of oral tobacco, hard food like betel nut should be reduced. Sixthly, to improve Oro-dental health of the workers, usage of oral pipe should be reduced in their working place. These will help the workers to reduce exposure to lead. Finally, to combat the existing Oro-dental problems of the workers by regular and periodic dental checkup and giving necessary treatment, proper health education regarding dental hygiene.

Acknowledgement

The authors would like to thank to the owners of the battery factories from where we were able to collect valuable data for their precious insights and assistance in the conducting this study. We also appreciate the support and encouragement from our colleagues and institutions.

Funding

This research received no external funding. The authors have not received any financial support for the research, authorship or publication of this article.

Conflicts of interest

All the authors declared no conflicts of interest regarding the publication of this paper. All research and findings presented are free from any commercial or financial relationships that could be construed as a potential conflict of interest.

REFERENCES

1. Van de Rijt LJM, Stoop CC, Weijenberg RAF, de Vries R, Feast AR, et al. The Influence of Oral Health Factors on the Quality of Life in Older People: A Systematic Review. Gerontologist. 2020 Jul; 60 (5): 378-394.

2. Peres MA, Macpherson LMD, Weyant RJ, Daly B, Venturelli R, et al. Oral diseases: a global public health challenge. Lancet. 2019 Jul; 394 (10194): 249-260.

3. Kapila YL. Oral health's inextricable connection to systemic health: Special populations bring to bear multimodal relationships and factors connecting periodontal disease to systemic diseases and conditions. Periodontol. 2000. 2021 Oct; 87 (1): 11-16.

4. Kaur KK. Control of Somatostatin Receptor 2 (SSTR2) by Proinflammatory, Microbial and Obesity Associated Signals in Gingival Crevicular Fluid, Role of Visfatin and Other Adipokines in Obesity with Periodontitis, Diurnal Rhythms-A Systemic Review to Update Association of oral Health with Obesity. EC Dental Science. 2020 Dec; 19 (1): 01-11.

5. Ren YF, Rasubala L, Malmstrom H, Eliav E. Dental Care and Oral Health under the Clouds of COVID-19. JDR Clin Trans Res. 2020 Jul; 5 (3): 202-210.

6. Hessain D, Dalsgaard EM, Norman K, Sandbak A, Andersen A. Oral health and type 2 diabetes in a socioeconomic perspective. Prim Care Diabetes. 2023 Oct; 17 (5): 466-472.

7. Yuwanati M, Gondivkar S, Sarode SC, Gadbail A, Desai A, et al. Oral health-related quality of life in oral cancer patients: systematic review and meta-analysis. Future Oncol. 2021 Mar; 17 (8): 979-990.

8. Carasol M, Muñoz Aguilera E, Ruilope LM. Oral health, hypertension and cardiovascular diseases. Hipertens Riesgo Vasc. 2023 Oct; 40 (4): 167-170.

9. Petersen PE, Bourgeois D, Ogawa H, Estupinan-Day S, Ndiaye C. The global burden of oral diseases and risks to oral health. Bull World Health Organ. 2005 Sep; 83 (9): 661-669.

10. Lamster IB. The 2021 WHO Resolution on Oral Health. Int Dent J. 2021 Aug; 71 (4): 279-280.

11. Kandelman D, Arpin S, Baez RJ, Baehni PC, Petersen PE. Oral health care systems in developing and developed countries. Periodontol 2000. 2012 Oct; 60 (1): 98-109.

12. Nazir MA. Prevalence of periodontal disease, its association with systemic diseases and prevention. Int J Health Sci (Qassim). 2017 Apr; 11 (2): 72-80.

13. Khurana S, Jyothi C, Dileep CL, Jayaprakash K. Oral health status of battery factory workers in Kanpur city: A cross-sectional study. Journal of Indian Association of Public Health Dentistry. 2014 Apr; 12 (2) :80-87.

14. Sudhanshu S, Pankaj A, Sorabh J, Nidhi S. Dental Diseases of Acid Factory Workers Globally-Narrative Review Article. Iran J Public Health. 2014 Jan; 43 (1): 1-5.

15. Lussi A, Jaeggi T. Erosion--diagnosis and risk factors. Clin Oral Investig. 2008 Mar; 12 Suppl 1(Suppl 1): S5-13.

16. Dawes C. What is the critical pH and why does a tooth dissolve in acid? J Can Dent Assoc. 2003 Dec; 69 (11): 722-724.

17. Skogedal O, Silness J, Tangerud T, Laegreid O, Gilhuus-Moe O. Pilot study on dental erosion in a Norwegian electrolytic zinc factory. Community Dent Oral Epidemiol. 1977 Sep; 5 (5): 248-251.

18. Gomes ER. Incidence of chromium-induced lesions among electroplating workers in Brazil. IMS Ind Med Surg. 1972 Dec; 41 (12): 21-25.

19. Amin WM, Al-Omoush SA, Hattab FN. Oral health status of workers exposed to acid fumes in phosphate and battery industries in Jordan. Int Dent J. 2001 Jun; 51 (3): 169-174.

20. Gottesfeld P, Pokhrel AK. Review: Lead exposure in battery manufacturing and recycling in developing countries and among children in nearby communities. J Occup Environ Hyg. 2011 Sep; 8 (9): 520-532.

21. Were FH, Moturi MC, Gottesfeld P, Wafula GA, Kamau GN, et al. Lead exposure and blood pressure among workers in diverse industrial plants in Kenya. J Occup Environ Hyg. 2014 Sep; 11 (11): 706-715.

22. Hoet P. Speciation of lead in occupational exposure and clinical health aspects. Handbook of Elemental Speciation II–Species in the Environment, Food, Medicine and Occupational Health. 2005 Apr; 25 (1): 252-276.

23. Polanyi K. Developing Industrial Materials. Materials Matter: Toward a Sustainable Materials Policy. 2001 May; 25 (1): 21-23.

24. Kendler BS. Environmental Lead Contamination: A Metaphor for Destructive Industrial Practices; Lead Abatement: A Model for Ineffective Societal Responses. Structural Survey. 1994 Jun; 12 (3): 13-23.

25. Nordberg G, William Sunderman Jr F. Metals: Chemical properties and toxicity. Encyclopaedia of occupational health and safety. 1998 May; 3 (1): 43-63.

26. Stellman JM. The ILO encyclopedia of occupational health and safety: A multidisciplinary challenge. International Labour Review. 1998 Jul; 137 (3): 410-418.

27. Osinsky D, Stellman JM. Minerals and agricultural chemicals. Encyclopaedia of Occupational Health and Safety. 1998 Jul; 3 (1):1-12.

28. Kosnett MJ, Wedeen RP, Rothenberg SJ, Hipkins KL, Materna BL, et al. Recommendations for medical management of adult lead exposure. Environ Health Perspect. 2007 Mar; 115 (3): 463-471.

29. Tong S, von Schirnding YE, Prapamontol T. Environmental lead exposure: a public health problem of global dimensions. Bull World Health Organ. 2000 Mar; 78 (9): 1068-1077.

30. Proshad R, Kormoker T, Mursheed N, Islam MM, Bhuyan MI, et al. Heavy metal toxicity in agricultural soil due to rapid industrialization in Bangladesh: a review. International Journal of Advanced Geosciences. 2018 Apr; 6 (1): 83-88.

31. Sample size calculator of research. Available from: http://www.macorr.com/ss_calculator.htm. (Last accessed on 2022, January 15).

32. Tuominen M, Tuominen R, Ranta K, Ranta H. Association between acid fumes in the work environment and dental erosion. Scand J Work Environ Health. 1989 Oct; 15 (5): 335-338.

33. Ahmad SA, Khan MH, Khandker S, Sarwar AF, Yasmin N, et al. Blood lead levels and health problems of lead acid battery workers in Bangladesh. Scientific World Journal. 2014 Feb; 2014 (974104): 1-7.

34. Suyama Y, Takaku S, Okawa Y, Matsukubo T. Dental erosion in workers exposed to sulfuric acid in lead storage battery manufacturing facility. Bull Tokyo Dent Coll. 2010 Apr; 51 (2): 77-83.

35. Almeida TF, Vianna MI, Santana VS, Gomes Filho IS. Occupational exposure to acid mists and periodontal attachment loss. Cad Saude Publica. 2008 Mar; 24 (3): 495-502.

36. Raj JB, Gokulraj S, Sulochana K, Tripathi V, Ronanki S, Sharma P. A cross-sectional study on oral health status of battery factory workers in Chennai city. J Int Soc Prev Community Dent. 2016 Mar; 6 (2): 149-153.

37. Petersen PE, Gormsen C. Oral conditions among German battery factory workers. Community Dent Oral Epidemiol. 1991 Apr; 19 (2): 104-106.

38. Kundu H, Basavaraj P, Singla A, Gupta R, Jain S, Singh K. Oral health status among workers of lead acid battery factories in Ghaziabad: A cross-sectional study. Journal of Indian Association of Public Health Dentistry. 2017 Apr; 15 (2): 127-130.

39. Suvan J, D'aiuto F. Assessment and management of oral health in obesity. Current Obesity Reports. 2013 Jun; 2 (1): 142-149.

40. Keller A, Rohde JF, Raymond K, Heitmann BL. Association between periodontal disease and overweight and obesity: a systematic review. J Periodontol. 2015 Jun; 86 (6): 766-776.

41. Moghaddam LF, Vettore MV, Bayani A, Bayat AH, Ahounbar E, et al. The Association of Oral Health Status, demographic characteristics and socioeconomic determinants with Oral health-related quality of life among children: a systematic review and Meta-analysis. BMC Pediatr. 2020 Oct; 20 (1): 489-503.

42. Baniasadi K, Armoon B, Higgs P, Bayat AH, Mohammadi Gharehghani MA, et al. The Association of Oral Health Status and socio-economic determinants with Oral Health-Related Quality of Life among the elderly: A systematic review and meta-analysis. Int J Dent Hyg. 2021 May; 19 (2): 153-165.

43. Yang Y, Liang L, Cai J, You J, Liao X. Improving oral hygiene for better cognitive health: Interrelationships of oral hygiene habits, oral health status, and cognitive function in older adults. J Adv Nurs. 2024 Jan; 80 (1): 275-286.

44. Gunjal S, Pateel DGS, Yang YH, Doss JG, Bilal S, et al. An Overview on Betel Quid and Areca Nut Practice and Control in Selected Asian and South East Asian Countries. Subst Use Misuse. 2020; 55 (9): 1533-1544.

45. Gajendra S, McIntosh S, Ghosh S. Effects of tobacco product use on oral health and the role of oral healthcare providers in cessation: A narrative review. Tob Induc Dis. 2023 Jan; 21 (1): 12-27.

46. Calzada MT, Posada-López A, Gutiérrez-Quiceno B, Botero JE. Association Between Tobacco Smoking, Dental Status and Self-perceived Oral Health in Elderly Adults in Colombia. J Cross Cult Gerontol. 2021 Jun; 36 (2): 187-200.

47. Tenelanda-López D, Valdivia-Moral P, Castro-Sánchez M. Eating Habits and Their Relationship to Oral Health. Nutrients. 2020 Aug; 12 (9): 2619-2626.

48. Butera A, Maiorani C, Morandini A, Simonini M, Morittu S, et al. Evaluation of Children Caries Risk Factors: A Narrative Review of Nutritional Aspects, Oral Hygiene Habits, and Bacterial Alterations. Children (Basel). 2022 Feb; 9 (2): 262-275.

49. Elamin A, Garemo M, Gardner A. Dental caries and their association with socioeconomic characteristics, oral hygiene practices and eating habits among preschool children in Abu Dhabi, United Arab Emirates. BMC Oral Health. 2018 Jun; 18 (1): 104-112.

50. Paszynska E, Cofta S, Hernik A, Otulakowska-Skrzynska J, Springer D, et al. Self-Reported Dietary Choices and Oral Health Care Needs during COVID-19 Quarantine: A Cross-Sectional Study. Nutrients. 2022 Jan; 14 (2): 313-323.