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Occupational Stressors in Lead-Acid Battery Production: Health Risks from Environmental Strain, Noise, and Chemical Exposure from Factories in Savar, Bangladesh

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ABSTRACT

The purpose of this study is to examine the health risks and occupational hazards that employees in Bangladesh's lead-acid battery manufacturing sector encounter. A total of 150 randomly chosen male participants—mostly between the ages of 25 and 40 and with three to eight years of experience in the industry—were asked structured questions during the survey. Their working conditions, health problems associated with lead exposure, and demography were all covered in the poll. The results showed that a high frequency of health issues, such as neurological symptoms, nausea, gastrointestinal disorders, and exhaustion, were closely linked to hazardous working environments. Extreme heat, loud noises, and exposure to harmful substances, particularly lead, are some of these dangerous circumstances. The study found strong links between unfavorable health outcomes and unfavorable working conditions using statistical analysis performed with IBM SPSS version 25. In the lead-acid battery business, the report emphasizes the critical need for increased workplace safety and more stringent environmental regulations. It is imperative to improve these protocols in order to safeguard employees from detrimental exposures and to encourage environmentally friendly industrial processes. The well-being of employees can be considerably increased by implementing ecologically friendly industrial methods and upholding stricter occupational safety regulations. By drawing attention to these important concerns, the study promotes a more environmentally friendly and health-conscious method of conducting industrial processes, guaranteeing that workers are protected from the negative consequences of hazardous work conditions. This research is one of the first to offer a thorough analysis of the health risks and occupational hazards unique to Bangladesh's manufacture of lead-acid batteries in the Savar region. It offers helpful recommendations for improving workplace safety, bridges awareness gaps among employees, and highlights the importance of eco-friendly activities. It is a significant addition to industrial health research because of its all-encompassing methodology and regional emphasis. The goal of this research is to assist the long-term sustainability of the sector and aid in the establishment of rules that safeguard the health of workers.

Keywords: Health Risks, Occupational Hazards, Lead Exposure, Workplace Safety, Environmental Regulations, Sustainability

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1. Introduction

One of the most common occupational and environmental health issues worldwide is lead poisoning [1]. Employment in the lead acid storage battery industry is only one of many occupations in Bangladesh that are high risk for elevated blood-lead levels [2]. More than 50% of employees had blood lead levels over the acceptable threshold (5 µg/dL), per a 2014 survey of educators at Bangladesh University of Engineering and Technology (BUET) [3]. When lead from these batteries is improperly disposed of, it can harm the local ecosystem and result in lead poisoning. Lead poisoning is a major public health issue that might have a negative impact on people's health [6].Tremor, complete drop wrist drop, increasing weakening, pain in the muscles and joints, lack of appetite and stomachache, blue line along the gums, diarrhea, constipation, vomiting, and high blood pressure are all indicators of a potential lead poisoning health concern[2] Bangladesh is directly concerned about heavy metals like lead, which provide a particular environmental risk related to human activity and might pose a threat in the present and the future[2]. Bangladesh employs a wide variety of batteries. Among the several battery chemistries available, lead batteries are among the most dependable and reasonably priced varieties that may be utilized for a variety of energy storage applications [4]. In figure 1, Lead-acid batteries are now used for everyday purposes in many market-sector applications [5]. Major lead-acid battery companies manufacture and export lead-acid batteries for both domestic and international markets. Bangladesh is home to many industries that specialize in exporting lead-acid battery products [3]. Dust transition in the air, which was enriched by lead can be a source of contamination for plants as well as soil and water reserves. They could even end up on dinner plates. Its physical, chemical and biological characteristics as well as biogeochemical processes may affect lead solubility, bioavailability and toxicity in given redox conditions [6]. The objective of this study was to examine the association between health outcomes among workers and their exposure heat, noise and chemical in lead acid battery (LAB) factories; therefore, a field survey was conducted in Savar region of Bangladesh. It further called for a more rigorous occupational safety standards adherence and enforcement in addition to alerting to the health hazards of lead toxicity.

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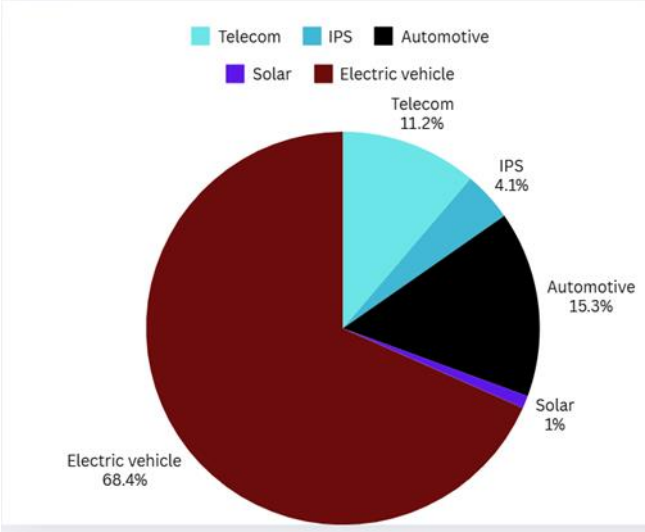
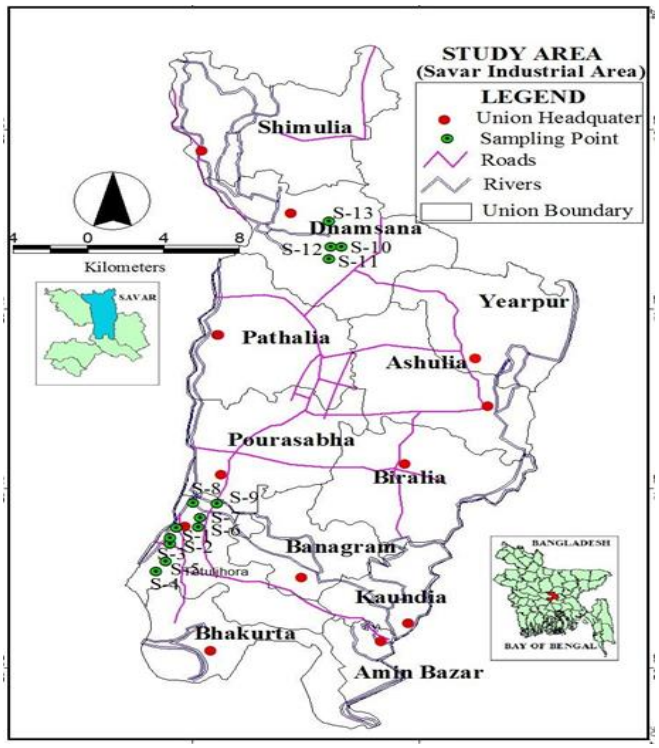


Fig 1. The lead-acid battery markets estimated distribution in Bangladesh

2. Study materials and methodology

2.1. Study design and area selection

This study was conducted in the Savar Upazila, located approximately 24 kilometers northwest of Dhaka City in the Dhaka District of Bangladesh. Covering an area of 280.11 square kilometers, Savar Upazila lies between latitudes 23°44' and 24°02' north and longitudes 90°11' and 90°22' east.



2.2. Ethical acceptance

The Rajshahi University of Engineering and Technology, RUET's Ethical Committee examined and approved the study design and methodology at Rajshahi-6204, Bangladesh.

2.3. Participant's Selection & Data Collection:

150 male employees were randomly chosen from a variety of lead-acid battery manufacturing companies in Bangladesh's Savar district in this study. Employees above the age of 18 having at least one year of experience in their respective positions were given priority during the selection stage. Participants represented thirteen employment groups, including operators, laborers, quality controllers, supervisors, security guards, technicians, officers, engineers, attendants, electricians, maintenance personnel, medical assistants, and peons. This stratified sample technique ensures a representative cross-section of the workforce by collecting data from a variety of job categories so that health consequences and occupational stressors can be accurately assessed.

2.4. Study tools and data collection

The data was collected via a well-structured Q&A session, which included a face-to-face interview with a variety of questions. The Q&A session was split into three segments, with approximately 150 people participating. Table 1 contains participant information (age, gender, educational background, employment experience, etc.).Table 2 focuses on workplace conditions such as chemical smells, humidity control issues, the presence of dust, and so on. Table 3 discusses the health issues that workers encounter as a result of lead acid exposure .Before the session, all participants provided written consent after being told of the study's aims. The data were taken during the working periods of the participants, and each session took around 5 to 10 minutes. Over 30 days, 15 field excursions were performed to collect data. A highly skilled, experienced field research assistant was selected to assist with data collection and interviewing. The Q&A session was conducted in Bengali to ensure that all participants understood.

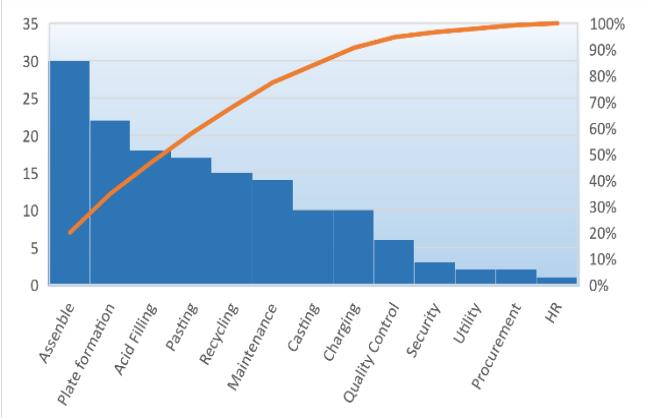


Fig 2. Frequencies and percentages of workers are categorized by working sections

2.5. Data analysis:

IBM SPSS version 25 was used to perform the statistical analyses. Categorical variables were evaluated using frequencies and percentages. The mean (M) and standard deviation were used to interpret the continuous variables. All analyses were performed in two stages. During the first stage, we determined the variables' frequency and percentile. The top nine frequencies of negative job patterns and working environments were then discovered among the participants. We used descriptive statistics to determine the relationships between the top nine lead exposure symptoms, job patterns, and working environments.

3.Results

3.1. Participants' details

The participants' demographic and professional details are presented in Table 1, Table 2, and Figure 2. Among the 10

designated roles identified, the majority (42.67%) were laborers, followed by battery technicians, who comprised 26.67% of the workforce. Regarding working areas, the assembling section had the highest number of participants, whereas the human resources (HR) department had the least representation. The gender distribution showed that around 70% of the workers were male, with the remaining 30% being female. A considerable majority of the participants (40%) were between the ages of 25 and 40. According to the educational background analysis in Table 1, 53.6% of the participants had finished higher secondary education, while just 4.6% had graduated from university. Furthermore, Table 1 shows that nearly half of the participants (50%) had three to eight years of job experience.

3.2. Work designation

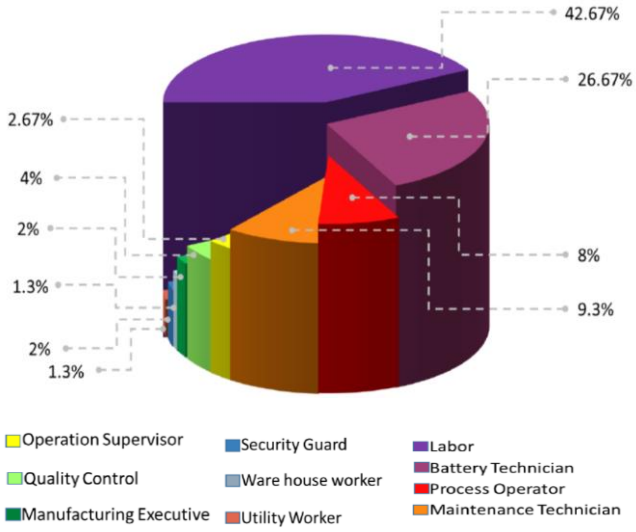


Fig3. Percentages of participants according to job designations.

Work patterns at lead-acid battery production plants include a wide range of job categories, each of which is crucial to the industry's overall operational efficiency. A thorough investigation of labor composition indicates the distribution of job types and their respective percentages. Process operators account for around 8% of the overall workforce. These operators are largely responsible for hands-on assembly and manufacturing procedures that have a direct impact on the production process. Laborers account for approximately 43% of the workforce and assist operators with tasks such as material handling and machine operation. Quality controllers, who make up approximately 4% of the workforce, supervise production processes to ensure that set safety and quality standards are maintained. Operation supervisors, who constitute around 3% of the workforce, are in charge of ensuring that safety protocols are implemented. Security guards, who account for around 2% of the workforce, safeguard the facility's safety and security, including employee and asset protection. Maintenance technicians make up approximately 9% of the workforce and are in charge of maintaining and repairing machinery and equipment to ensure that activities function smoothly. Battery technicians make up around 27% of the workforce and are responsible for battery assembly, testing, and calibration. Manufacturing executives account for about 2% of the workforce and are in charge of safety, workforce management, and other duties. Warehouse workers, who make up around 1.5% of the workforce, are responsible for loading and unloading, order picking and packaging, inventory management, and other tasks. Utility workers represent approximately 1.5% of the workforce and perform a variety of support activities such as trash collection, cleaning, and sanitation.

3.3. Work pattern

Table1. Participants' work patterns in details

Variables		Frequency percent (n=150)	Percent
Age range of participants'	<25 years	53	35
	25-40 years	60	40
	>40 years	37	25
Gender	Male	105	70
	Female	45	30
Education background of the participants	Primary pass	11	7.3
	SSC pass	52	34.6
	HSC pass	30	53.5
	University	7	4.6
Work experience	3 years	30	20
	3-8 years	75	50
	>8 years	45	30
Where did they work before taking this job?	First job	93	62.3
	Textiles	34	22.6
	Chemical industry	16	10.6
	Another battery industry	7	4.5
Type of the participants	Permanent	135	90
	Non-permanent	15	10
Overtime work participants	Yes	44	29.3
	No	106	70.7
Work with modern machine	Yes	84	56
	No	16	44
Seating facilities	Yes	45	30
	No	105	70
Awareness of using PPE	Yes	130	86.6
	No	20	14.4
Night shift	Yes	60	40
	No	110	60
Shifting time	<=8 hours	58	38.6
	>8 hours	112	61.4
Living facilities	Quarter	15	10
	Outside	135	90

The study encompassed 150 participants, with 40% aged between 25 and 40 years. An additional 35% were under the age of 25, while 25% were over the age of 40. Regarding educational qualifications, 34.6% of participants held a Secondary School Certificate, whereas 7.3% had completed only primary school, and 4.6% had attained a university degree. Men comprised approximately 70 percent of the workforce. In terms of job experience, 50% of persons had three to eight years of experience, 20% had less than three years, and 30% had more than eight years. The employment status revealed that 90% of the workers were permanent, with only 10% being temporary. In terms of overtime work, 29.3% of respondents acknowledged doing so, while the remaining 70.7% did not.

3.4. Condition of workplace

Table2. Workplace environment

Variables		Frequency percent (n=150)	Percent
Room temperature of uncomfortable workplace	Absent	130	86.6
	Present	20	13.4
Acid(H_2SO_4) handle condition	Absent	119	79.4
	Present	31	20.6
Presence of fume in the workplace	Absent	140	93.3
	Present	10	6.7
Chemical smell available in workplace	Absent	129	86
	Present	21	14
Unbearable sound present in workplace	Absent	110	73.3
	Present	40	26.4
Humidity control issue	Absent	100	66.6
	Present	50	33.4
Presence of dust	Absent	90	60
	Present	40	40

In a study of 150 people's workplaces, several environmental variables were examined to determine their presence and frequency. A noteworthy 86.6% (130 participants) reported no uncomfortable room temperatures, whereas 13.4% (20 participants) confirmed their presence. In handling sulfuric acid (H_2SO_4), 79.4% (119 participants) stated no concerns, whereas 20.6% (31 individuals) reported recent issues. The presence of occupational fumes was limited, with 93.3% (140 participants) claiming no exposure and 6.7% (10 participants) confirming it. Similarly, 86% (129 participants) did not identify chemical scents, but 14% (21 persons) acknowledged their presence. Noise levels were an issue for 26.4% (40 participants), whereas 73.3% (110 participants) reported no oppressive sound levels. Humidity control appeared as a cause for concern, with 33.4% (50 participants) reporting troubles, while 66.6% reported no problems. 40% (60 participants) acknowledged the presence of dust, whereas the remaining 60% (90 participants) showed little concern. These findings indicate a variety of environmental factors that could impact worker comfort and safety.

3.5. Participants health condition

A thorough evaluation of the individuals revealed a number of health issues. Fatigue was reported by 25.3% of individuals (38), and weakness by 22.6% (34). 20.6% (31 participants) experienced abdominal pain, while 6.7% (10 participants) reported nausea and vomiting. 10.6% (16 persons) reported constipation, while 6% (9 participants) lost weight. Anemia was reported by 40% of subjects (60), and numbness by 41.3% (62). 30% (45 persons) reported reproductive issues, whereas 29.3% (44 participants) had proteinuria. Hematuria afflicted 20% (30 participants), whereas 3.4% (5 participants) reported reduced renal function. 20% (30 people) reported behavioral changes, 14% (21 people) had headaches, and 13.4% (20 people) complained of annoyance 3.4% (5 people) experienced memory issues, whereas 4.7% (7 participants) reported decreased focus. 18% (27 people) had hypertension, while 4% (6 persons) reported a risk of malignancy. 4.7% (7 participants) experienced seizures, while 3.4% (5 participants) were in danger of coma.18% (27 participants) reported hyperactivity, and 2.7% (4 participants) felt tingling. 4% (6 people) reported respiratory problems, 17.3% (26 participants) had vision issues, and 2% (3 participants) had skin problems. Finally, 4% (6 patients) had lead in their blood. In terms of injuries, 2% (3 individuals) had hand injuries, 2% (3 participants) had leg injuries, and 1.3% (2 participants) suffered eye injuries. This thorough study focuses on the serious health consequences of workplace lead exposure.

4. Discussion

The present study found a quantitative survey of thermo-environmental strain, auditory degradation, chemical toxicant exposure, and the correlative health deterioration of lead-acid battery production workers in Bangladesh. There were a total of 150 respondents included in this study who worked in lead-acid battery production factories. The above pie chart, according to job designation, showed ten categories of participants who have been performed during the survey of this study. The maximum number of participants were laborers (42.67%), the second maximum number of participants were battery technicians (26.67%), and the minimum number of participants were security guards and utility workers (1.3%). Participant's information tables showed that this survey was done by 70% male participants. The maximum age range of participants was 25-40 years. To identify the education status, half of the participants had higher secondary level education (53.5%). That means maximum workers are not well educated. 70% of participants reported that they had no seating facilities. Among them, 57.14% had anemia, and 25.71% had hypertension. This study also discovered that 29.3% of participants worked overtime. 56% of participants work with modern machines, and 40% of participants worked at the night shift. This study also revealed 61.4% of participants worked more than 8 hours. A huge amount of workers (90%) living outside the industry. A number of people had awareness of using Personal Protection Equipment (PPE) during work. About 86.67% of the workers used Personal Protection Equipment (PPE) during their work. Among them, only 4.61% had a risk of cancer, and 3.07% had tingling problems. 3.84% had memory loss problems, 2.30% had skin disease problems, 7.69% had nausea and vomiting problems, and 3.70% had bone problems. This study had been greatly affected by the condition of the workplace. In our study, 13.4% of participants worked with uncomfortable room temperature. 20.6% of participants handled acid (H_2SO_4) in production time. Only 6.7% of participants reported the presence of fume in the workplace, 40% of participants worked in the presence of dust, and 26.4% of participants reported that they had worked in the presence of unbearable sound. Our initial research on participants' exposure to potentially harmful chemicals and physical agents is really valuable. This is due to the fact that a sizable portion of Bangladeshi workers engage in this activity, and the majority of the country's occupational health experts are ignorant of this circumstance among these workers, many of whom have low socioeconomic positions and little education [6]. Prolonged exposure to lead can be hazardous, affecting the neurological, gastrointestinal, hematological, renal, and reproductive systems and increasing the risk of developing a number of disorders [1]. Therefore, prolonged exposure to dust raises the possibility of developing disorders linked to dust, including cancer, asthma, allergic alveoli, irritability, and non-respiratory ailments [7]. The employees complained about the excessive heat in the workspace and voiced

concerns regarding inadequate lighting and ventilation [1].The following practices can further minimize worker exposure in addition to ensuring proper ventilation: offering an isolated eating area situated away from operations; supplying a ventilated room, maintained at positive pressure and with processed air, for the removal of ventilators [8]. A study of lead batteries for utility energy storage provides an overview of the performance of lead batteries in energy storage applications and highlights how they have been adapted for this application in recent developments [4]. Another study was conducted with investigation and evaluation of children's blood lead levels around a lead battery factory and identified some important influencing factors such as age, gender, distance from industry, and parent's occupation that actually affect the children's blood lead levels[9].Whereas our study is conducted on a survey of a total of 150 male participants about their working conditions and health problems associated with lead exposure and tries to assist the long-term sustainability of the sector and establish a safeguard for the health of workers. Another study provides blood lead levels and health problems of lead-acid battery workers in Bangladesh by collecting a 5 mL blood sample. This survey was conducted with a total of 118 workers from 15 selected industries [1]. Our primary objective is to pinpoint the workplace issues that lead to various illnesses and implement preventative measures. This research has certain restrictions as well. The participants' participation in the survey had been based solely on their assumptions. This isn't the real approach to obtain precise outcomes. We needed some test-based data in order to obtain more precision. Nonetheless, this is just the initial phase of identifying the health condition that is associated with Bangladesh's lead-acid battery manufacturing sector. This preliminary questionnaire may prove useful for researchers in the future.

Table 3. Lead Exposure Syndromes in Lead-Acid Manufacturing Workers

Variables		Frequency percent (n=150)	Percent
1.Fatigue	Yes	38	25.3
	No	112	74.7
2.Weaknes	Yes	34	22.6
	No	116	77.4
3. Abdominal pain	Yes	31	20.6
	No	119	79.4
4. Nausea and vomiting	Yes	10	6.7
	No	140	93.3
5. Constipation	Yes	16	10.6
	No	134	89.4
6. Weight loss	Yes	9	6
	No	141	94
7. Anemia	Yes	60	40
	No	90	60
8. Numbness	Yes	62	41.3
	No	88	58.7
9.Reproductive problems	Yes	45	30
	No	105	70
10. Proteinuria	Yes	44	29.3
	No	106	70.7
11. Hematuria	Yes	30	20
	No	120	80
12. Decreased kidney function	Yes	5	3.4
	No	145	96.6
13.Behaviour changes	Yes	30	20
	No	120	80
14. Headache	Yes	21	14
	No	129	86
15. Irritability	Yes	20	13.4
	No	130	86.6
16. Memory problems	Yes	5	3.4
	No	145	96.6
17. Decreased concentration	Yes	7	4.7
	No	143	95.3
18. Hypertension	Yes	27	18
	No	123	82
19. Risk of cancer	Yes	6	4
	No	144	96
20. Seizures	Yes	7	4.7
	No	143	95.3
21.Risk of coma	Yes	5	3.4
	No	145	96.6
22.Hyperactivity	Yes	27	18
	No	123	82
23. Tingling	Yes	4	2.7
	No	146	97.3
24. Respiratory problem	Yes	6	4
	No	144	96
25.Eye sight issue	Yes	26	17.3
	No	124	82.6
26. Skin problem	Yes	3	2
	No	147	98
27.Bones' problem	Yes	4	2.7
	No	146	97.3
28.Pb Presence in blood	Yes	6	4
	No	144	96
29.Injury type	Hand	3	2
	Leg	3	2
	Eye	2	1.3

In table 4, our overall observations are discussed.

5.Conclusion

This study discusses the occupational pressures that workers endure in lead-acid battery manufacturing plants, emphasizing the critical need for improved workplace safety measures. According to the report, while these facilities help to boost economic growth, they also represent considerable health hazards to workers due to severe heat, high noise levels, and harmful chemicals. These hazardous working conditions have resulted in a wide range of health problems, including tiredness, nausea, vomiting, constipation, and weight loss. Creating a less hazardous working environment would benefit employees' health. Although many businesses have begun to adopt environmentally friendly production techniques, numerous gaps remain. As a result, the goal of this research is to enhance workplace conditions and lower health hazards.

Table 4. Section-wise, the eight top most lead exposure-related syndromes

Section	Numbness		Anemia		Reproductive problem		Proteinuria		Fatigue		Weakness		Abdominal pain		Hematuria	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
1.Assemble	6 (20%)	24 (80%)	6 (20%)	24 (80%)	9 (30%)	21 (70%)	9 (30%)	21 (70%)	9 (30%)	21 (70%)	7 (23.3%)	23 (76.7%)	8 (26.6%)	22 (74.4%)	8 (26.6%)	22 (74.4%)
2. Plate formation	8 (36.3%)	14 (63.7%)	8 (36.3%)	14 (63.7%)	9 (40.9%)	13 (59.1%)	9 (40.9%)	13 (59.1%)	7 (31.8%)	15 (68.2%)	8 (36.3%)	14 (63.7%)	7 (31.8%)	15 (68.2%)	6 (27.27%)	16 (72.73%)
3. Acid Filling	10 (55.5%)	8 (44.5%)	8 (44.5%)	10 (55.5%)	6 (33.3%)	12 (66.7%)	6 (33.3%)	12 (66.7%)	6 (33.3%)	12(66.7%)	6 (33.3%)	12 (66.7%)	4 (22.22%)	14 (77.78%)	4 (22.22%)	14 (77.78%)
4. Pasting	7 (41.2%)	10 (58.8%)	7 (41.2%)	10 (58.8%)	5 (29.4%)	12 (70.6%)	5 (29.4%)	12 (70.6%)	4 (23.5%)	13 (76.5%)	3 (17.6%)	14 (82.4%)	2 (11.8%)	15 (88.2%)	2 (11.8%)	15 (88.2%)
5. Recycling	5 (33.3%)	10 (66.7%)	5 (33.3%)	10 (66.7%)	3 (20%)	12 (80%)	3 (20%)	12 (80%)	2 (13.3%)	13 (86.7%)	1 (6.6%)	14 (95.4%)	1 (6.6%)	14 (95.4%)	1 (6.6%)	14 (95.4%)
6. Maintenance	5 (35.7%)	9 (64.3%)	5 (35.7%)	9 (64.3%)	2 (14.3%)	12 (85.7%)	2 (14.3%)	12 (85.7%)	1 (7.14%)	13 (92.86)	1 (7.14%)	13 (92.86)	1 (7.14%)	13 (92.86)	1 (7.14%)	13 (92.86)
7. Charging	7 (70%)	3 (30%)	7 (70%)	3 (30%)	4 (40%)	6 (60%)	4 (40%)	6 (60%)	3 (30%)	7(70%)	2 (20%)	8 (80%)	2 (20%)	8 (80%)	2 (20%)	8 (80%)
8. Casting	6 (60%)	4 (40%)	6 (60%)	4 (40%)	3 (30%)	7 (70%)	3 (30%)	7 (70%)	3 (30%)	7(70%)	3 (30%)	7 (70%)	3 (30%)	7 (70%)	3 (30%)	7 (70%)
9. Quality Control	3 (50%)	3 (50%)	3 (50%)	3 (50%)	1 (16.6%)	5 (85.4%)	1 (16.6%)	5 (85.4%)	1 (16.6%)	5 (85.4%)	1 (16.6%)	5 (85.4%)	1 (16.6%)	5 (85.4%)	1 (16.6%)	5 (85.4%)
10. Security	2 (33.3%)	1 (66.7%)	2 (33.3%)	1 (66.7%)	1 (66.7%)	2 (33.3%)	1 (66.7%)	2 (33.3%)	1 (66.7%)	2 (33.3%)	1 (66.7%)	2 (33.3%)	1 (66.7%)	2 (33.3%)	1 (66.7%)	2 (33.3%)
11. Utility	1 (50%)	1 (50%)	1 (50%)	1 (50%)	1 (50%)	1 (50%)	1 (50%)	1 (50%)	1 (50%)	1(50%)	1 (50%)	1 (50%)	1 (50%)	1 (50%)	1 (50%)	1 (50%)
12. Procurement	1(50%)	1(50%)	1(50%)	1(50%)	1(50%)	1(50%)	0(100%)	0(100%)	0(100%)	0(100%)	0(100%)	0(100%)	0(100%)	1(50%)	1(50%)	1(50%)
13. HR	1 (100%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)
Total	62 (41.3%)	88 (58.7%)	60 (40%)	90 (60%)	45 (30%)	105 (70%)	44 (29.3%)	106 (69.7%)	38 (25.3%)	112 (74.7	34 (22.7%)	116 (87.3%)	31 (20.7)	119 (79.3%)	30 (20%)	120 (80%)

References

[1] Sk. A. Ahmad *et al.*, "Blood Lead Levels and Health Problems of Lead Acid Battery Workers in Bangladesh," *The Scientific World JOURNAL*, vol. 2014, pp. 1–7, Jan. 2014

[2] F. Ahmed, K. M. Bahauddin, A. Kadir, and I. Kamal, "Exploring Health Problems among Lead Acid Storage Battery Workers in Dhaka City, Bangladesh," *American Journal of Pure and Applied Biosciences*, pp. 1–12, Jan. 2023

[3] M. B. Islam, M. Khalekuzzaman, S. B. Kabir, and Md. M. Rana, *A Study on Recycling Used Lead-Acid Batteries (ULABs) in Bangladesh*. 2021, p. 1.

[4] G. J. May, Focus Consulting, International Lead Association, Advanced Lead-Acid Battery Consortium, A. Davidson, and B. Monahov, "Lead batteries for utility energy storage: A review," 2018.

[5] Ariful Islam, "formulation of a process to improve pce & reduce waste of a lead acid battery industry by using lean six sigma model," MSc thesis, Bangladesh University of Engineering and Technology, 2019.

[6] S. Das *et al.*, "Occupational Hazards in Lead-acid Battery Factories in Bangladesh: Assessing Excess Heat, Noise, Chemical Exposures, and Health Impacts on Workers," *Safety and Health at Work*, Jul. 2024.

[7] A. A. Nayeem and Department of Environmental Science, Stamford University Bangladesh, Dhaka, Bangladesh, "Pollution and Perceptions of Lead in Automobile Repair Shops in Dhaka, Bangladesh," *Journal of Health & Pollution*, vol. 9, no. 22, pp. 1–2, Jun. 2019.

[8] B. Schaddelee-Scholten, J. Tempowski, and World Health Organization, *Recycling used lead-acid batteries: health considerations*. 2017.

[9] F. Zhang *et al.*, "Investigation and Evaluation of Children's Blood Lead Levels around a Lead Battery Factory and Influencing Factors," *International Journal of Environmental Research and Public Health*, vol. 13, no. 6, p. 541, May 2016.