Research Article

Epidemiology of Workplace Accident among the Ferroalloy Industries in Bhutan

Phuntsho Dendup[1], Twisuk Punpeng[2], Chaweewon Boonshuyar[3]

Abstract

Workplace accident has a devastating and long term effect on the lives of people who are affected. Globally, workplace accidents are estimated at 317 million annually and 6300 workers die daily of occupational diseases and accidents. This study determines the characteristic of workplace injuries, accident frequency rate (AFR), accident severity rate (ASR) and leading causes across six ferroalloy industries in Bhutan. From the total numbers of 1366 workers, a sample size of 300 was considered and distributed proportionately among the companies and the departments within the companies. Information was gathered through face-to-face interview, observation, and secondary data maintained by each company. This study found that the workplace injury rate was 200 (20%) per 1000 workers, with over all AFR 62.45 and ASR 583.20 per million hours of work annually among the six ferroalloy industries. Out of 561 lost working days, 516 days were lost due to major injury with AFR 11.45 and ASR 540.20 per million hours work annually. This study found that AFR alone cannot be used as an exclusive indicator for predicting the occurrence of severe events at workplace. Contact with object and equipment (44.2%), fall from height (20.9%) and contact with the hot substance (26.7%) were three main leading causes of workplace accidents among ferroalloy industries. Comparing between the survey data and accident record maintained by each company, though it showed a similar nature, the frequency was found to be higher in survey data.

Keywords: Workplace injury, Accident frequency rate, Accident severity rate, Ferroalloy industry

Introduction

Workplace accident sets off a cascade of effects throughout the personal and professional lives of everyone affected. The results are devastating and long-term, thus workplace accidents are a significant global issue. International Labour Office (ILO) estimated 317 million occupational accidents occur every year and daily 6300 people die of occupational accidents and diseases.[4] In Bhutan, the Department of Labour (DoL) reported the highest number of accidents in the construction industry (60%) followed by manufacturing industry (33.3%) and, trading and service sector (1.6%) in the year 2015-16.[2] In the same year, fatal accidents were recorded at 40% followed by partial disability 57% and total disability by 7% among the reported accidents. However, the reports also highlighted that many accidents go unreported to the Department and statistics illustrated might be a tip of the iceberg. Similarly, the Ministry of Health has reported 25,203 work-related injuries in 2015.[5]

The cause of accidents differs in many ways based on the job and the industries. Literature has underlined the importance of understanding the contributing factors to accident causation in order to devise successful interventions to prevent

[1]Faculty of Public Health, Thammasat University, Thailand and Department of Labour, Ministry of Labour and Human Resources Thimphu, Bhutan.

[2]DS, [3]Associate Professor, Faculty of Public Health, Thammasat University, Thailand.

Correspondence: Mr. Phuntsho Dendup, Thammasat University, Thailand and Department of Labour, Ministry of Labour and Human Resources Thimphu, Bhutan.

E-mail Id: phuntshodendup@gmail.com

Orcid Id: http://orcid.org/0000-0001-5867-7389

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them.[1,14,15] According to the Health and Safety Executive (HSE), being struck by moving vehicles (22.6%), falls from a height (18.2%) and being struck by a moving, including flying or falling object (14.6%) were the three main causes of fatal injury in the year 2016-17.[7] The US Department of Labour identified transport incidents aside from roadway accidents (16.4%), contact with object and equipment (15%) and falls, slips, trips (fall to lower level) (13.4%) were the three main causes of fatal injury in the year 2015.[17] The top 10 frequently cited OSHA standards violated in years 2016 were: fall protection, hazard communication, scaffolding, respiratory protection, control of hazardous energy (lockout/tagout), powered industrial trucks, machinery and machine guarding, electrical (wiring, methods, components and equipment) and electrical system design.

Workplace accident is a costly affair. It is estimated that 1.25 trillion dollars are lost to occupational accidents and diseases.[4] Furthermore, ILO estimated an average of 4% of global gross domestic product (GDP) lost due to workplace accidents.[13] Health and Safety Executive (HSE) had estimated about 30.4 million working days were lost in the year 2015-16 and cost about £14.1 billion due to workplace injury and illness (19% by the employers, 57% by the individual and, 24% by the government) in the United Kingdom.[6] In USA, the workplace accidents that resulted in absence from work for six days or more had cost US companies $59.9 billion per year and more than $1 billion a week on the most disabling, nonfatal workplace injury.[10] According to the Department of Labour, in Bhutan the cost of workmen's compensation alone account to Nu 6.64 million, which is equal to 0.01% of its GDP in the year 2015-16.[2] The cost of workplace accident is very heavy to the individual, employers and the society at large both in terms of financial and non-monetary aspects, hence leading to social and economic losses.

This paper examines the prevalence and leading causes of workplace accidents among ferroalloy industries in Bhutan. Ferroalloy industrial workers are exposed to chemical hazards, heat radiation, hazards imposed by heavy machinery, noise, silica dust, dangerous gases, etc.[9,16] The tapping and casting, preheating, and reproduction areas have several safety challenges as the workers are in close proximity to molten silicon and high heat. In the ferroalloy industry in Kazakhstan, about 29% of the total accidents are contributed by objects in translation motion, rotation or flight followed by 18% due to effect from hazardous substances and chemicals.[9]

Occupational Health and Safety (OHS) in Bhutan is at an emerging stage. The broader understanding of OHS at workplace only began in 2007 when the Labour and Employment Act (LEA) of Bhutan 2007 was enacted[3] and the regulations on OHS promulgated only in the year 2012. The LEA, particularly Chapter IX, deals with OHS and is applied to all types of employment with the aim to maintain a safe and healthy workplace. However, the annual report 2015-16 of DoL indicated the lack of capacity in implementing OHS standards to be the principal constraint. Resistance from the employers and employees on the acceptance of OHS culture and under-reporting workplace accidents are some of the major challenges that DoL faces.[2]

Ferroalloy industries of Bhutan are chosen as the subject for this research work even though there is no sufficient evidence to show that these industries are more hazardous than other industries in Bhutan. This is because of limited or non-availability of specific studies done on the workplace accidents in ferroalloy industries in Bhutan as well as no studies on over all workplace accidents in Bhutan. The purpose of this study is to determine the prevalence of workplace accidents and leading causes among the ferroalloy industries in Bhutan.

For the purpose of this study, severity of accidents was classified into three types: (i) minor – an accident that could cause an injury that is treated by applying first aid as a result of injury or accident, (ii) moderate – an accident that could cause an injury requiring medical treatment beyond first aid or unable to perform their normal work duties for more than three consecutive days as the result of their injury, and (ii) major – an accident that results in serious injury leading to permanent partial disability such as fractured or cracked bones, teeth, loss of fingers, unable to perform their normal work duties for more than seven consecutive days as the result of their injury or transferred to another job.

Materials and Methods

Study Design and Population

The study was a cross-sectional study conducted in ferroalloy industries in Bhutan. This study had considered all the ferroalloy (6) industries located in Phuntsholing employing 1366 workers. A sample size of 300 is estimated from the population, considering a maximum allowable error of 5% (d=0.05) at 95% confidence level and 33% (p=0.33) as the reference prevalence taken from the accident prevalence rate for manufacturing industry in Bhutan.[2] To overcome incomplete responses, 10% is added on the sample size derived. The sample size was distributed proportionately to each industry and also among the department within the industry. Systematic random sampling was used to recruit the workers from each department.

Analysis

Data was collected through face-to-face interview, observation and secondary data maintained by each company. The workplace injury, accident frequency and severity rate were calculated using the following methods:[8]

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$$\text{Workplace Injury Rate} = \frac{Number\ \text{of injuries}}{Total\ numbers\ of\ employees} \times 1000 \text{ per man hours work}$$

$$\text{Accident Frequency Rate} = \frac{Number\ of\ injuries}{Total\ hours\ worked} \times 10^6 \text{ per man hours work}$$

$$\text{Accident Severity Rate} = \frac{Number\ of\ days\ lost}{Total\ hours\ worked} \times 10^6 \text{ per man hours work}$$

The upper (UL) and lower (LL) level of 95% CI for injury, AFR and ASR were defined using Poisson confidence interval formula.

$$LL = \frac{x^2_{\frac{a}{2},2d}}{2} \qquad UL = \frac{x^2_{1-\frac{a}{2},2(d+1)}}{2}$$

Ethical Approval

The study was approved by Ethical Review Sub-committee for involving human research subject of Thammasat University (Faculty of Health Science and Science and Technology) via approval reference COA No. 315/2560.

Results

General Characteristics of Workers

Table 1 shows the profile of the 300 workers who participated in the survey. 75.3% were male and 24.7% were female workers with an average age of 32.48 (sd=8.93) years. The age of participants ranged from 18 to 56 years old. Married workers represented higher proportion (66.7%) compared to other marital status. Workers with higher education attainment showed the lowest percent of participation. The average work experience of the workers was 4.62 years (sd=4.79) ranging from less than one year to maximum of 27 years. Most workers were employed as regular workers (75.7%).

Table 1.General Characteristics among 300 Workers

General Characteristics	Number	Percent
Gender		
Male	226	75.3
Female	74	24.7
Age in years		
Mean 32.48, SD 8.93, Min 17, Max 56		
18–24	55	18.3
25–34	146	48.7
35–44	58	19.3
45+	41	13.7
Marital status		
Single	92	30.7
Married	200	66.7
Divorce/separated	8	2.7
Educational attainment		
Uneducated	82	27.3
Grade 1–10	98	32.7
Grade 11–12	81	27.0
Bachelors and above	39	13.0
Work experience (in years)		
Mean 4.62, SD 4.79, Min <1, Max 27		
< 1	72	24.0
1–2	55	18.3
3–4	57	19.0
5–9	83	27.7
10–19	23	7.7
≥20	10	3.3
Types of employment		
Regular	227	75.7
Casual	73	24.3

Workplace Injury

The study found that the workplace injury rate was 20% which was two times higher than the record maintained by the companies (10%) over the last one year. 75% of workplace accidents had resulting in minor injury, 16.7% moderate injury, and 18.3% major injury. More than one-third (36.7%) of workers who had experienced workplace accidents were absent from work at least one day to a maximum of 90 days with an average 9.35 days of absence from work as shown in Table 2.

Table 2.Types of Workplace Injuries and Days Absence among 300 Workers

Characteristics	Number	Percent
Workplace accident	60	20.0
Types of accidents		
Minor	45	75.0
Moderate	10	16.9
Major	11	17.3
Days absence due to injury among 60 workers experienced workplace accident		
Mean 9.35, SD 22.02		
0	38	63.3
1–3	7	11.7
4–6	1	1.7
7 and above	14	23.3

Lost Working Days

Table 3 (End of the article) shows the number of working days lost. Over the last one year, 561 working days were lost by ferroalloy industries. 519 working days were lost to major injury, 36 to moderate injury, and 6 to minor injury. The company A was found to have lost the highest numbers of days (186) due to workplace accidents while company C lost the lowest number of days (2).

Table 4 displays the accident records maintained by the companies. In the last one year, the record maintained by the companies reveal 144 (10%) workplace accidents. A total of 435 working days were lost to workplace accidents, of which 370 working days to major injury, 24 to moderate and 41 to minor injury. The data on accident record maintained by each company illustrates that company A (205) had lost the highest numbers and company C (7) the least.

When these two sets of data were compared, the information revealed that the higher numbers of working days were lost to major injury, and that among the companies, the company A had lost higher numbers of working days and company C had lost the lowest

Accident Frequency Rate (AFR)

The survey data showed that the accident frequency rate was 62.45 for every one million hours worked over the last one year. The AFR for minor injury was 46.85 per one million hours of work which is higher than moderate and major injury type as illustrated in Table 3. Among the companies, the AFR for company C (114.85) was found to be Highest while company B (6.11) had the lowest as shown in Fig. 1 and Table 3. The other four companies had about the same range of AFR.

The accident record maintained by each company shows the overall AFR (33.72) for every one million hours worked for the last one year. Among the injury types, the AFR for minor injury was found high (21.55). Similarly, company E had Highest AFR (109.79) among the companies as illustrated in Table 4. (End of the article).

Both the datasets reveal that the major injury had a higher AFR over the last one year. AFR for company C and E were comparatively higher in both the datasets.

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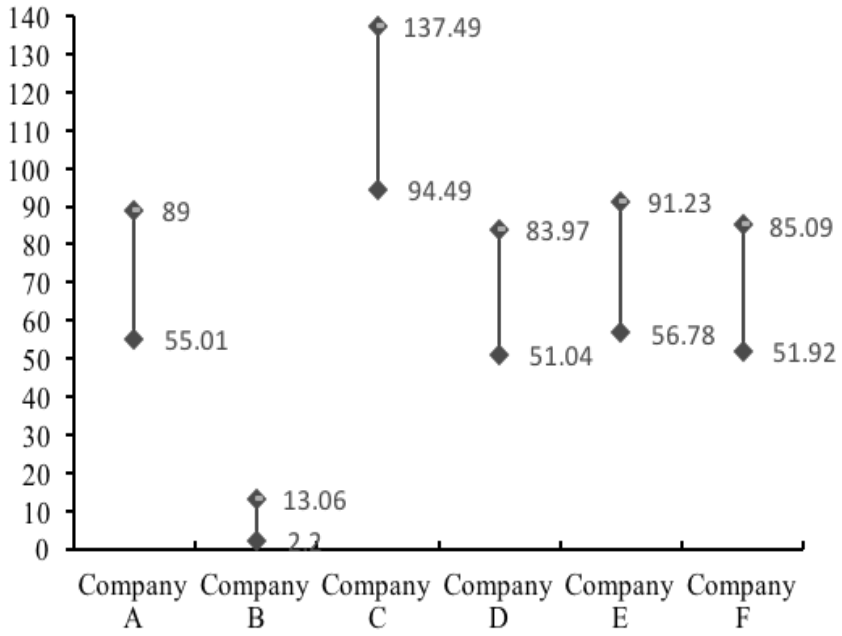

Figure 1.Comparison of AFR among the companies with 95% CI from survey data

Accident Severity Rate (ASR)

Table 3 illustrates an ASR from the survey data. The survey data illustrates ASR was 583.91 per one million man hours of work over the last one year. The ASR for major injury was 540.20 per one million man hours worked which is higher than moderate and minor injury types. Among the companies, company D had the highest ASR (1102.66) followed by company A (821.80), F (594.77), and the lowest with company C (241.76).

The accident record maintained by each company illustrates an overall ASR of 101.87 per one million man hours worked over the last one year. The ASR was found higher among major injury (86.65). Company-wise, higher ASR was observed in company A (209.52), F (111.32), D (105.09) and lowest in company C (17.36). The details are illustrated in Table 4.

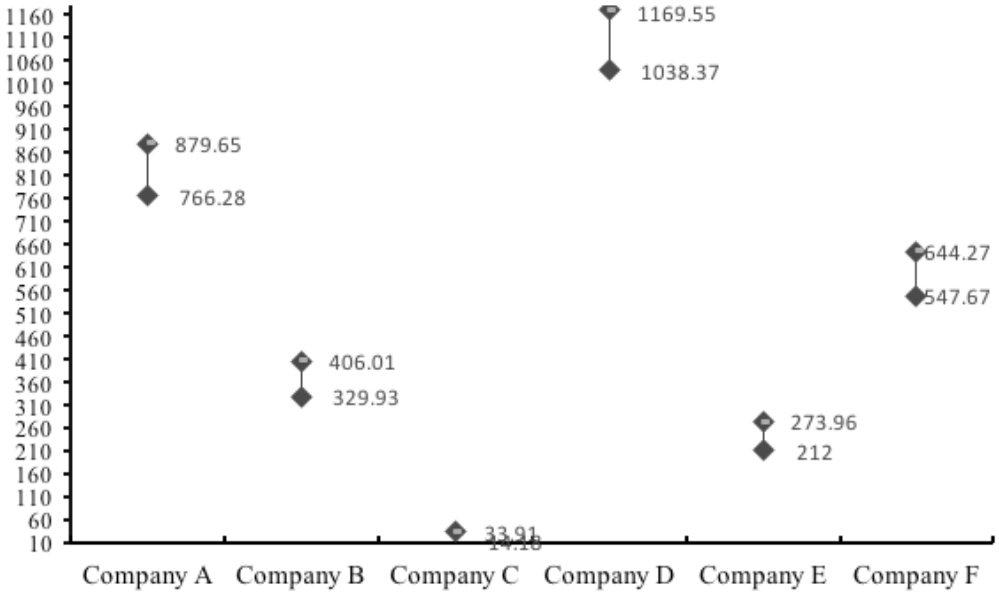

Figure 2.Comparison of ASR among the companies with 95% CI from survey data

Leading Causes of Injury due to Workplace Accidents

From the total of 144 accidents recorded, 86 (excluding company E) were further classified according to the types of causes as shown in Table 5. One of the leading causes of workplace injuries in ferroalloy industries was contact with object and equipment (44.2%). The second leading cause was contact with hot substance (26.7%), and followed by fall from height 20.9%. The data maintained by the companies shows that Company E had Highest number of accidents (19.6%) and the least recorded was by Company F (4.7%) and D (4.8%).

Table 5.Number and percent of workplace accident by cause in six ferroalloy industries in the last one year

Company	No of workers	Accident		Cause of workplace accident							
		n %		Fall from height		Contact with object/ equipment		Contact with hot substance		Others[1]	
				n	%	n	%	n	%	n	%
	1366	144	10.5	18	20.9	38	44.2	23	26.7	7	8.1
A	313	32	10.2	11	34.4	7	21.9	12	37.5	2	6.3
B	252	23	9.1	3	13.0	14	60.9	5	21.7	1	4.3
C	129	13	10.1	2	15.4	8	61.5	2	15.4	1	7.7
D	207	10	4.8	1	10.0	4	40.0	4	40.0	1	10.0
E[2]	169	58	19.6	-	-	-	-	-	-	-	-
F	296	8	4.7	1	12.5	5	62.5	0	0.0	2	25.0

[1]Slip and trip, electric shock and others

[2]Information on the cause of accident was not available

Discussion

This study found the workplace injury rate among the six ferroalloy industries to be 200 (20%) per 1000 workers annually, which is 1.7 times lower than the overall manufacturing workplace injury rate (33.3%) reported in 2015-16 by *DoL* Bhutan.[2] Minor injury showed more than four times higher rate (150) of workplace accidents than moderate (33.3) and major (36.67) in the survey data as illustrated in Table 3. Higher proportion of minor injury in this study could be due to inclusion of injuries that required only first aid treatment and no absenteeism. It is important that every incident is counted irrespective of severity to measure the safety performance of the organization.

The survey and accident records maintained by each company illustrate higher accident frequency rate (AFR) of minor injuries than moderate and major as shown in Tables 3 and 4. Both the datasets show higher number of lost working days and ASR (survey: 540.2, record: 86.65) due to major injury than other types of injury. This indicates that workers who had suffered major injury had taken longer time to return to work. The study found that the overall ASR (583.91) was five times higher in survey data than the record maintained by the companies (101.87).

Comparing AFR and ASR among the six ferroalloy industries from the survey data, the results showed that company C had the highest AFR (114.85) but with the lowest ASR (22.97) and company D had the highest ASR (1102.66) but relatively lower AFR (66.16) as shown in Table 3 and Figs. 1 and 2. The findings indicate that company C had more of minor workplace injuries that did not result in lost working days, while company D had more of accidents that could have resulted into major injury and more loss in working days since company D's ASR is higher among all the companies indicating the poor safety performance. Similarly, the recorded data demonstrates that companies D and F had the lowest AFR (D=15.45; F=8.65) but quite higher ASR (D=109.09; F=111.32) while company E had higher AFR (109.79) but lower ASR (39.75) as illustrated in Table 4.

In this study, both datasets illustrated that higher claims of AFR are not necessarily reliable indicators for occurrence of severe injury or event. Figure 1 illustrated that company B had the lowest AFR of 6.11 (95% CI 2.2–13.06) and company C with the highest AFR of 114.85 (95% CI 94.49–137.49). Going by the traditional theory that frequency breeds severity,[11,12,18] company C is expected to have higher ASR with the higher claims of AFR. However, company C showed the lowest ASR 22.97 (95% CI 14.18–33.91) as depicted in Fig. 2. Similar cases were also found in other companies as discussed above. Over the decades, safety professionals had been focusing on reducing minor injuries to reduce major injuries. Recent study found that AFR of an organization could be unreliable predictor of severity occurrence.[11] The finding of this study indicate that low AFR does not provide any assurance for non-occurrence of major events and that preventative measures should be taken beyond elimination of minor injuries. Since this finding was limited to one year data and a cross-sectional study among six industries, further in-depth study is suggested to support the findings.

Comparing two sets of data, the survey data showed a comparatively higher workplace injury rate than the data maintained by the companies. This illustrates poor reporting and recording system in the company. However, both the datasets depict similar trends. The reason for the difference in datasets could be due to lack of proper accident recording and reporting systems in the companies and poor safety culture. Firstly, lack of proper accident recording and reporting systems can lead to inconsistent reporting and recording system in the workplace. Many accidents may not get reported properly or the workers may refrain from reporting accidents due to unawareness or fear of losing their employment status. Secondly, the companies may not be serious on reporting and recording system in particular and OHS in general. This phenomenon

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could have arisen since OHS administration is new to Bhutan and lack of systematic enforcement of the legislation by the DoL. The OHS law was introduced only in 2007 and detailed standards in 2012. Though the Labour and Employment Act 2007 and the Regulations on Occupational Health, Safety and Welfare 2012 require every workplace accident to be reported to Department of Labour, many go unreported due to weak OHS administration. Furthermore, there is no occupational health surveillance system in place. Thus, it can be concluded that infant stage of OHS administration system could be one of the factors for poor safety culture in the companies.

This study found three leading causes of workplace accidents in ferroalloy industries: (i) contact with object and equipment (44.2%), (ii) contact with hot substance (26.7%), and (iii) fall from height (20.9%) as shown in Table 5. The contact with moving objects and equipment means being struck by moving objects/equipment including flying or falling objects. The contact with hot substance is mainly due to contact with the molten ore during the tapping work. The finding in this study supports the findings of Imangazin et al.,[9] where 29% of accidents were caused by contact with objects in translational motion, rotation or flight in a ferroalloy industry. The finding of this study on causes of accidents due to contact with objects and equipment showed 1.5 times higher than the findings of Imangazin et al.[9] This study had taken six ferroalloy industries as sample size over a year whereas the pervisous study had only one industry but records were examined for the last six years. The finding of the study is coherent to the recorded leading cause in UK and USA. HSE had reported fall from height (18.2%) and stuck by moving objects (14.6%) were the leading causes in UK for the year 2016-17.[7] The US BLS reported contact with object and equipment (15%) and fall from height (13.4%) were found to be the leading causes of accidents in the US for the year 2015.[17] Even though the percentages were quite high in this study, it is coherent to previous study and reports on the leading cause of accident in workplace.

Conclusion

This is the first ever cross-sectional study conducted on the prevalence of workplace accidents in Bhutan in general and among the ferroalloy industries in specific. Though the findings provide information, the opportunities for comparisons to previous study are limited at global context and none in Bhutanese context, therefore limiting comparison.

The examination of the survey result showed workplace injury rate was two times higher compared to record maintained by each company. The ASR for major injury was found to be more than six times higher in survey data than data maintained by each company. The overall AFR was 62.45 and ASR 583.91 over a year among 300 workers. Examining the AFR and ASR within the organization indicates that traditional theory of frequency breeds severity cannot be used as exclusive indicator for predicting an occurrence of severe event. The two sets of data used for examination of workplace accidents show a similar trend though the figures are quite high in the survey data than in accident recorded data. Among the causes of workplace accidents, contact with objects and equipment, fall from height and contact with hot substance were three main leading causes among ferroalloy industries.

The availability of information on the workplace accidents in Bhutan is very limited both at the national and companies level even though the legislation is in place. Higher workplace accidents are found to be triggered by poor safety culture which can only be improved with the strong enforcement of the legislation by the government agencies like DoL. Hence, it suggests the importance of OHS legislation enforcement and compliance among the industries in Bhutan. OHS being at an evolving stage, initiatives by the government agencies through advocacy, training programs and other educational supports should be the priorities. This study is only limited to six ferroalloy industries in Bhutan and does not include other industries, workers' compensations and other associated cost incurred due to workplace accidents. This study leaves these limitations for further studies.

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Conflict of Interest: None

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Table 3.Workplace accident, frequency, and severity rate in six ferroalloy industries among 300 participants

Industry	No of sample workers	No of injury	Days lost[1]	Hours of work[2]	Workplace Injury (per 1000 workers)			Accident Frequency (per 1000,000 hours work			Accident Severity (per 1000,000 hours work)		
					Rate	95%CI		Rate	95%CI		Rate	95%CI	
						Lower	Upper		Lower	Upper		Lower	Upper
All	300	60	561	960761	200.00	173.24	229.72	62.45	47.54	79.48	583.91	537.11	632.82
Company A	70	16	186	226333	228.57	199.83	260.13	70.69	55.01	89.00	821.80	766.28	879.65
Company B	53	1	60	163617	18.87	11.05	29.06	6.11	2.20	13.06	366.71	329.93	406.01
Company C	28	10	2	87073	357.14	320.92	396.02	114.85	94.49	137.49	22.97	14.18	33.91
Company D	44	9	150	136035	204.55	177.43	234.53	66.16	51.04	83.97	1102.66	1038.37	1169.55
Company E	38	9	30	124089	236.84	207.32	268.64	72.53	56.78	91.23	241.76	212.00	273.96
Company F	67	15	133	223614	223.88	195.16	254.80	67.08	51.92	85.09	594.77	547.67	644.27

[1]No. of days lost in a year due to injury

[2]Annual hours of work (including overtime) of 300 workers in the last one year. It is estimated based on the reported hours of work and overtime in a week by the workers and not the actual hours maintained by the company.

Table 4.Workplace accident, frequency, and severity rate in six ferroalloy industries in the last one year based on records

Industry	No of workers	No. of injuries	Days lost[1]	Hours of work[2] Rate	Workplace Injury (per 1000 workers)			Accident Frequency (per 1000,000 hours worked)			Accident Severity (per 1000,000 hours worked)		
					Rate	95%CI		Rate	95%CI		Rate	95%CI	
						Lower	Upper		Lower	Upper		Lower	Upper
All	1366	144	435	4270116	105.42	85.88	127.11	33.72	23.13	46.93	101.87	82.72	123.27
Company A	313	32	205	978438	102.24	83.17	123.82	32.71	22.30	45.76	209.52	182.09	239.87
Company B	252	23	31	787752	91.27	73.27	111.73	29.20	19.42	41.65	39.35	27.73	53.31
Company C	129	13	7	403254	100.78	81.82	122.18	32.24	21.89	45.17	17.36	9.90	27.22
Company D	207	10	68	647082	48.31	35.39	63.64	15.45	8.40	24.74	105.09	85.88	127.11
Company E	169	58	21	528294	343.20	307.66	381.29	109.79	89.95	132.03	39.75	28.15	53.89
Company F	296	8	103	925296	27.03	17.79	39.28	8.65	3.78	16.43	111.32	91.31	133.67

[1]No. of days lost in a year due to injury

[2]1. Annual hours of work (including overtime) of 1366 workers in the last one year, 2. Hours of work was estimated based on 8 hour per day and 12 hour per week for last one year in accordance to hours of work standard of Bhutan.