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Adjust Jidoka Occupational Fatigue Factors to Reduce Idle Times and Defects Using Data Mining (case study)

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ABSTRACT

The Jidoka Occupational fatigue represents a major threat for the continuation of the work because generating idle times then defects that disable the productivity for more than 1 day (eg., casual vacation). The main objective of Jidoka is solving of mistakes that occur in a process. When there is an abnormal situation arises the machine, stops and the Labour will stop the production line. Automation (Jidoka) prevents the production of defective products; adjust over-process if necessary and focuses attention on understanding the problem and ensuring that it never recurs. This paper identifies the major factors increasing the risk of a fatal occupational fatigue and idle times in order to provide further evidence for the design and implementation of preventive measures in Jidoka settings. The CAPMAS registered occupational fatigue that causes absence and their characteristics in some industry cities. The fatal occupational fatigue was registered until mid of 2015 (n = 269) were compared to a sample of non-fatal fatigue in same year (n = 1153). Risks of idle-times adjusted by occupational factors significantly associated by logistic regression models. Compared to non-fatal, fatal occupational fatigue mostly produced by natural causes such movable devices|| labourers in narrow area. The fatigue parts of body were a head, terminals, or internal organs. The data-mining analysis showed increased risk of fatality after an idle times for males (adjusted odds ratio = 10.92; 95% Confidence), temporary labourers (5.18; 95%), and the risk increased with age and with advancing hour of the work shift (p for trends <0.01). The main purpose of the paper is to draw attention to join the occupational fatigue to the list of waste, which dealt with Lean. These data help to define priorities for programs that prevent occupational fatigue, idle times and defects.

1 INTRODUCTION

One Egyptian labor feels with fatigue every 2 hrs because of bad habits at work because they disregard the principles of lean cultures in their activities implementation (Egyptian Commission, 2015). Research on the causes of Fatal Occupational Fatigue (FOF) needed in order to improve preventive actions based on the scientific evidence as cited in (M. Hagberg et al., 1997). A wide range of personal and occupational factors, such as age, gender, educational level, occupational status or lifestyles, have been found to be related to the risk of suffering a fatal occupational fatigue as understood from (B. Bhattacherjee et al., 2003; N. Chau et al., 2004; G.C. Gauchard et al., 2003; R. Blumenthal 2012). In general, few etiological studies have been performed on this subject (F.G. Benavides et al., 2001), specially taking into account the complexity of variables which play a role in the occurrence of an occupational fatigue and which can modify the likelihood of a fatal result. Factors related to the occurrence of a FOF may act at several levels in addition to worker's environment conditions, such as the workplace (proximal environmental conditions), the work environment (work organization and conditions) or even the social and political levels (employment or economic policies) as cited in (E. Castejón and X. Crespán, 2005; M.A. Hernandez 2012). Epidemiological researches of FOF have a priority, since it can help to improve the knowledge of factors and mechanisms, which increase the probability of FOF. This paper is important to determine the effectiveness of the available preventive

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measures and interventions as cited in (B. Bonnechère 2014). In addition, the importance of this study is increasing the awareness of the magnitude of this problem among mass media, policymakers and the society as a whole (B. Thacker and J. MacKenzie, 2003) and (R. Blumenthal 2012). The aim of this study is to analyse the role of several occupational factors in the likelihood of fatal result lead to occupational fatigue that lead to idle times, in order to provide further evidence for the design and implementation of preventive measures in the occupational settings.

2 PROBLEM DESCRIPTIVE CHART

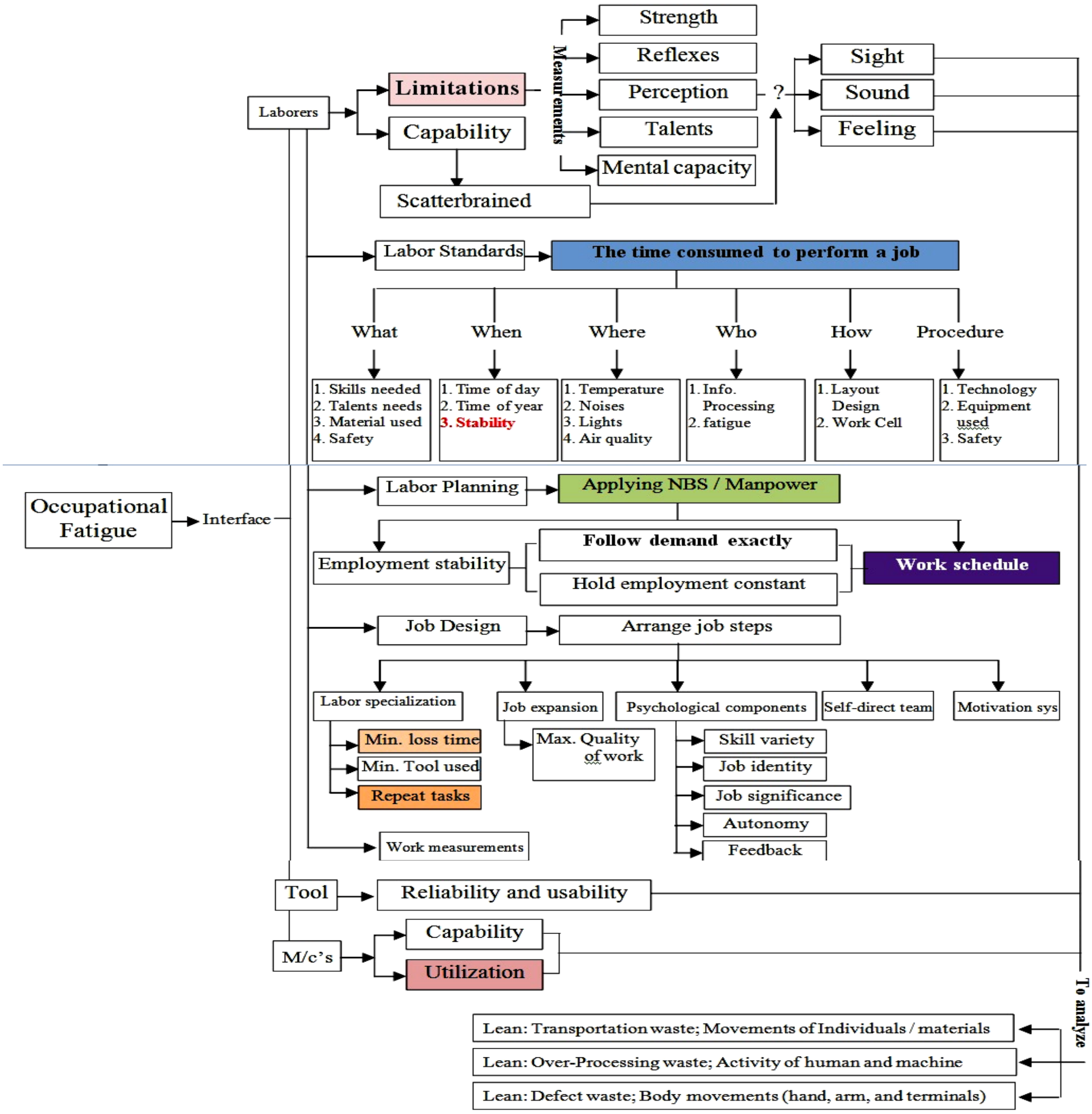

Fig. 1: The database of machine / labor interaction factors

databases for factories in 10th of Ramadan and El-Obour City in 2014 and 2015. Notification of occupational fatigue is mandatory in Egypt for companies, and reports contain, for each occupational fatigue causing at least 1 day of absence from work, these causes are interacted together and have some common themes. The database have information on the fatigued worker, on characteristics of his job and company, on circumstances of the adverse event related to the fatigue and on the nature and consequences of the fatigue as illustrated in previous "Fig. 1", all these databases were manipulated via data mining concept.

3 Problem Statement

The data of the study was obtained from the database of The CAPMAS (Central Agency for Public Mobilization and Statistics, Egyptian Commission, 2015), and collecting occupational fatigues registered in some of HR

In 2015, 21,309 occupational fatigue causing at least 1 day of absence from work were reported by companies and recorded by the HR departments.

All occupational fatigue reported as fatal (n = 269) or very serious (n = 1153) were included in the sample for this study, and 300 serious and slight fatigue as registered in the database were randomly selected from the remaining records. Traumatic occupational fatigue, commuting occupational fatigue, and relapses of former occupational fatigue were excluded. The factories have to switch between laborers during absence periods; the basic laborers called (m) and substituted laborers (sm)

"Fig .2" illustrates the main causes of fatigue happen and its percentage impact via enquiring random sample of workers in 10th of Ramadan and El-Obour factories; this figure is discussed in sequential tables from (Table-1 to Table-3), the time of this study is continuous two years. (Table-1) shows the variables related to occupational factors included in the Egypt Occupational Fatigue Notification Form and selected for this analysis. The immediate circumstances of events leading to occupational fatigue (Table-2), such as mechanism, exposure, and fatigued part of body, were compared for fatal and nonfatal occupational fatigue with X^2 test. To assess the role of occupational factors, adjusted odds ratios were obtained through logistic regression analysis including variables in (Table-1). A function was built from a saturated model selecting variables automatically backwards with the likelihood ratio criterion, with a significance level of 0.10 to exit. Significance of categories of selected variables was further tested with Wald test, and variables with most categories with $p > 0.10$ were taken out of the final function. The whole model was tested with Hosmer-Lemeshow test (Hosmer, David W.; Lemeshow 2013). All the analyses were performed with the statistical programs (e.g., Minitab for Windows).

4.1. The first dimension (Time)

This dimension have described as illustrated in "Fig. 3" to test the data validity and modernism before selection for analysis and can obtain it in time.

The model divide into five area, (A) illustrates the doubt area of data, therefore no selection for data before stability area (B), this area represents a good selection area for analysis, after this area observes modernism and validity avalanching, but can use data before area (D), because in area (E) no data valid. The time between (t_1) and (t_2) based on save the data with its modernism, but the span between (t_2) and (t_3) depends on appearing new data expose the problem, the span between (t_4) and (t_5) is very narrow, these boundaries are adjusting statistically by expert of stakeholders using brainstorming.

4.2. The second dimension (truest content)

In this section, the researcher depends on collect data from multi-sources using questionnaires or interviews with random sample of laborers in different sectors of manufacturing or services. Such as, the laborers who need muscles fitness to implement their works. This filter helps us to select data that has consensuses of laborers. This dimension interest in classify and make a group of laborers according to their reputation, experience and culture. The truest content model as illustrated in "Fig. 4" is divided to four creditability sectors.

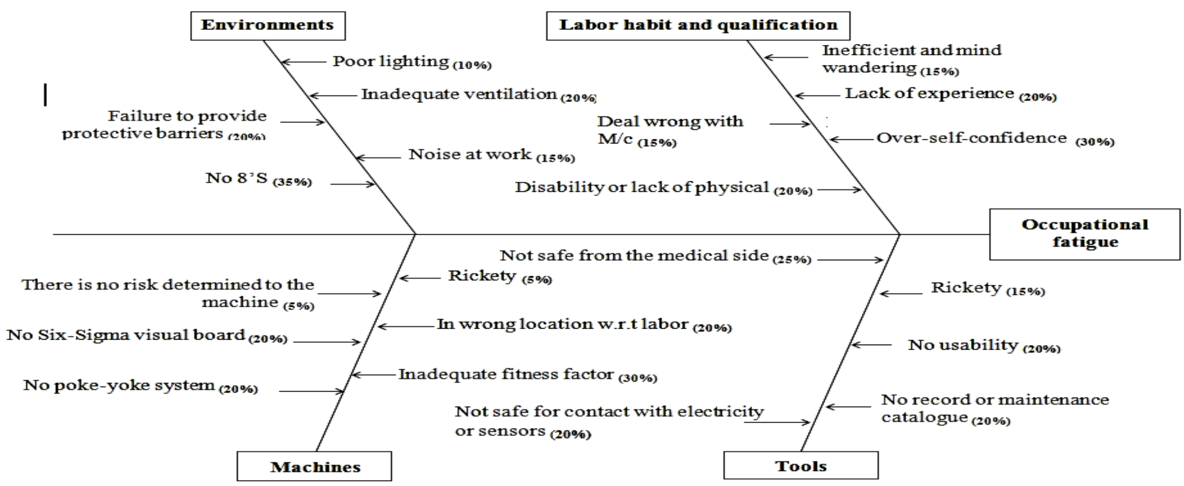

Fig. 2: Cause and effect diagram of occupational fatigue

4 Data Mining Analysis Methodology (data selection and pre-processing)

This paper takes into account the dimension of the data used in this analysis to generate "Fig. 2" and filtered this data by three filters. The first is the time dimension filter, which ensure from modernisms and validity of data. The second is the content dimension filter, which ensure from data truest, completion and has strongly relation with the problem statements. The third dimension filter is the model, which give us the ability of good treatment for the data and present the results and conclusion.

The sector (x^+, y^+) represents the laborers and HR databases which have a data has strong relation with the problem and viable, the sector (x^+, y^-) represents the group of HR databases and workers that have no relation with the problem, as illustrated by circle (E) and it abduced as circle (D). This paper based on data has more than one intersection between the circles in sector (x^+, y^+) with suitable weight (w_x) in horizontal direction and weight (w_y) in vertical direction. The data that collected from the group in circle (C) has large weights. As this think, the paper adjusts the percentage values of the root causes that appeared in the "Fig. 2" and have direct impact on occupational fatigue and lead to more than 1 day of absence or causes idle times.

The next stage is transforming all selected and pre-processing data for suitable database, but after using “Fig. 3” and “Fig. 4” models thinking to avoid any data inviable or has noises. The data appeared from (Table-1 to Table-3) is the data mining analysis results, which based on 1422 suitable data that led us to conclusion help in preventive the root causes of occupational fatigue or idle times. Remember, the main objective of this paper is achieving the continuity of the productivity and reduce the negative feeling of workers, may be getting their loyalty and efforts.

0.01) and 30% while performing an atypical job (14% for NFOF, p < 0.01). (Table-2) illustrates that circumstances of events (mechanism, involved agent and fatigued part of body) are compared. Most FOF were produced by overstrains, with 22 % of fatal fatigue and Strike, with 42% (34% and 42% for NFOF, respectively), “general” (as concluded from the database) agents (31% vs. 50% for NFOF), or Labor self-confidence (28% vs. 26% for NFOF, respectively).

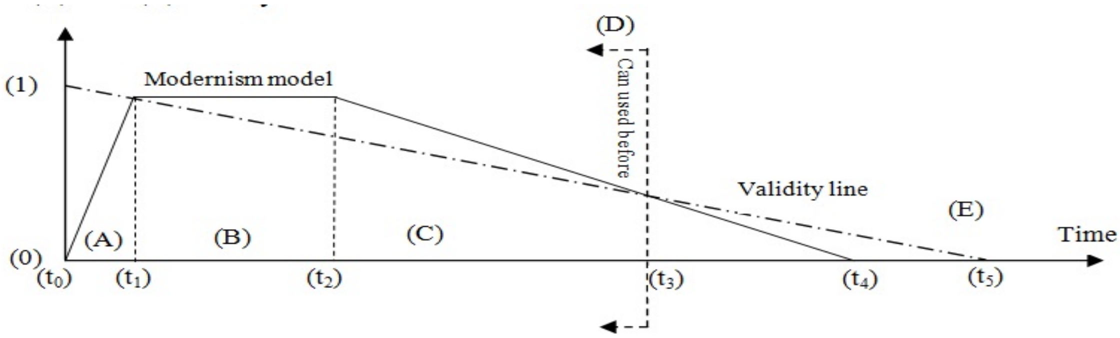

Fig. 3: The time dimension filter for selective data model

5 Data Mining Analysis Results

A total of 1422 occupational fatigue were considered. These include 269 fatal occupational fatigue (FOF) and 1153 non-fatal fatigue (NFOF). Detailed distribution of FOF and NFOF according to the different variables considered in the analysis that presented in (Tables-1 and 2).

As (Table-1) shows, more FOF than NFOF occurred in men ($p < 0.01$). In addition, fatally fatigued laborers were older than not fatally fatigued ($p < 0.01$; X^2 for linear trend = 48.75, $p < 0.01$). Most of FOF occurred in industrial laborers (35.68%), while the sector of services was the main sector of economic activity for NFOF (38.33%). 65% of FOF occurred in companies with less than 150 laborers (70% for NFOF), and 65% affected manual laborers (86% NFOF).

76% of FOF occurred in temporary employed laborers (54% for NFOF) and 68% were employed 6 months ago or less (42% for NFOF). A little more than a half of FOF (61%) happened in the central part of the work shift time, between 3rd and 6th hours, vs. 50% for NFOF (X^2 for linear trend = 12.61, $p < 0.01$). The mean time of employment for fatigued workers was for FOF and NFOF around 4 years ($p = 0.36$). No patterns were observed regarding the occurrence of FOF along the week but very small on Tuesday and have a maximum value on weekends, neither for NFOF.

15% of FOF happened on Saturday and 42% on weekends, while distribution of NFOF on the week varied from 28% on Sunday, 16% on Tuesday and 23% on weekends. More than a quarter of FOF (28%) occurred in atypical workplaces (11% for NFOF, p<

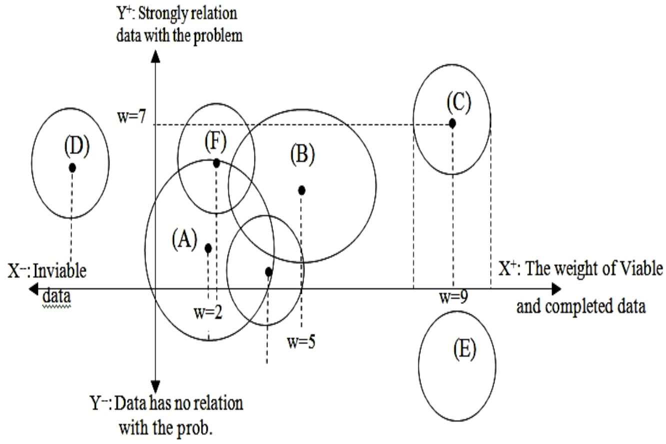

Fig. 4: The truest content dimension filter for selective data model

In addition, the NFOF of defective and tools, wrong device location represents 28% and 26% respectively. FOF affected often several parts of the body (84%) and NFOF affected mainly limbs (65%). As compared to non-fatal occupational fatigue, more FOF produced by natural causes or “other” (as registered in the database) causes ($p \leq 0.01$). Involved agents in FOF were more frequently elevation, transport devices, misuse of equipment and environment circumstances ($p < 0.01$), and the more frequently fatigued parts of body were internal organs, terminals or head ($p < 0.01$). On the other hand, downtimes produced by overstrain, by tools or devices, or affecting trunk or limbs, were significantly related to NFOF ($p \leq 0.01$).

Results from the adjusted analysis, with all NFOF considered altogether as controls and are shown in (Table-3). Male gender, increasing age, atypical workplace, atypical job tasks, working in job shop sectors, increasing hour of the work shift and temporary contract were all related to a fatal consequence after occupational fatigue.

Table 1: Jidoka characteristics in a sample of laborers suffering occupational fatigue in Egypt, 2015 (n = 1422)[a]. [7] [17]

	FOF [b] *n*(%)	NFOF [c] *n*(%)	P [d]
Sex			<0.01
Male	200 (74.34)	961 (83.34)	
Female	69 (25.26)	192 (16.65)	
Age (years)			<0.01
	23 (8.55)	195 (16.91)	
<25	62 (23.04)	**358 (31.04)**	
25–34	**73 (27.13)**	277 (24.02)	
35–44	58 (21.56)	204 (17.69)	
45–54	53 (19.7)	119 (10.32)	
>54			
Occupation [e]			<0.01
Skilled non-manual laborers	48 (17.84)	63 (5.46)	
Semi-skilled and unskilled non-manual workers	46 (17.1)	100 (8.67)	
Manual laborers	**175 (65.04)**	**990 (85.86)**	
Job tenure (months)			<0.01
0–6	**184 (68.4)**	**480 (41.63)**	
7–12	16 (5.94)	155 (13.44)	
13–36	27 (10.04)	215 (18.64)	
36–60	7 (2.6)	74 (6.41)	
>60	35 (13.01)	229 (19.86)	
Type of contract of employment			<0.01
Permanent	62 (23.04)	438 (37.98)	
Temporary	**204 (75.83)**	**620 (53.77)**	
Other	3 (1.11)	95 (8.23)	
Company size (utilization >=83%)			<0.01
≤150 laborers	**175 (65.05)**	**803 (69.64)**	
>150 laborers	94 (34.9)	350 (30.35)	
Economic activity			<0.01
Agriculture and packaging	50 (18.58)	94 (8.15)	
Industry			
Construction	**96 (35.68)**	307 (26.62)	
Services	54 (20.07)	330 (28.62)	
		422 (38.33)	
	69 (25.65)		
Job			<0.01
Usual	**238 (88.47)**	**1090 (94.53)**	
Atypical [f]	31 (11.52)	63 (5.46)	
Workplace (5'S) Principles			<0.01
Usual	**186 (69.14)**	**995 (86.29)**	
Atypical [g]	83 (30.85)	158 (13.7)	
Over Time Work shift hour			<0.01
<1.5 h	58 (21.56)	364 (31.56)	
1.5 – 2 h	**128 (47.58)**	**583 (50.56)**	
>2 h	83 (30.85)	206 (17.86)	
Time during one shift			<0.01
08–11 h (morning)	27 (10.03)	222 (19.25)	
11–01 h (afternoon)	29 (10.78)	138 (11.96)	
01–02 h (afternoon)	**166 (61.71)**	**571 (49.52)**	
02–04 h (night)	47 (17.47)	252 (21.85)	
Week day			0.04
Saturday	41 (15.24)	130 (11.27)	
Sunday	26 (9.66)	**325 (28.18)**	
Monday	26 (9.66)	156 (13.52)	
Tuesday	15 (5.57)	185 (16.04)	
Wednesday	48 (17.84)	90 (7.8)	
Thursday	**113 (42.00)**	267 (23.15)	

a: Sample includes all fatal and very serious occupational muscles fatigue (as reported to CAPMAS [10]) and a random selection of the remaining occupational muscles fatigue causing at least 1 day of absence from work.
b: FOF: fatal occupational fatigue (n = 269).
C: NFOF: non-fatal occupational fatigue (n = 1153).
d: p values for X^2 test.
e: Occupations were grouped in these three major categories based on the original occupations registered in the database according to the CAPMAS classification of occupations.
f: Different from everyday job.
g: Different from everyday workplace.

Table 2: Jidoka characteristics in a sample of laborers suffering occupational fatigue in Egypt, 2015 (n = 1422)[a]. [7]

	FOF [b] *n*(%)	NFOF *n*(%)	[c]P [d]
Mechanism of production			<0.01
Rickety	36 (13.38)	89 (7.7)	0.07
Strike	**114 (42.37)**	392 (33.99)	0.66
Overstrain	57 (21.18)	**485 (42.06)**	<0.01
Harmful substances	14 (5.2)	139 (12.05)	0.18
Natural causes [f]	16 (5.94)	22 (1.9)	0.01
Other	32 (11.89)	26 (2.25)	<0.01
Involved agent (5'S) Principles			<0.01
Noise, lighting and others	20 (7.43)	101 (8.75)	0.14
Movable devices			<0.01
Labor self confidence	31 (11.52)	208 (18.03)	<0.01
Defective Tools and	**84 (31.22)**	68 (5.89)	<0.01
equipment	52 (19.33)	**329 (28.53)**	0.01
Wrong Devices location	62 (23.04)	**296 (25.67)**	0.07
Engines	14 (5.2)	118 (10.23)	0.58
Other	6 (2.2)	33 (2.86)	
fatigued part			<0.01
Head	27 (10.03)	157 (13.6)	<0.01
Trunk	13 (4.83)	211 (18.3)	<0.01
Terminals	2 (0.743)	**755 (65.48)**	<0.01
Internal organs	**227 (84.38)**	30 (2.6)	<0.01

a: Same categories as included in the Egyptian Occupational Fatigue Notification Form and in the corresponding database used in this analysis. c: FOF: fatal occupational fatigue (n = 269).
b: Sample includes all fatal and very serious occupational fatigue (as reported to CAPMAS [10]) and a random selection of the remaining occupational fatigue causing at least 1 day of absence from work.
C: FOF: fatal occupational fatigue (n = 269).
d : NFOF: non-fatal occupational fatigue (n = 1153).
e: p values for X^2 test.
e: Occupations were grouped in these three major categories based on the original occupations registered in the database according to the Egyptian Social Security Administration classification of occupations.
g: Different from everyday workplace.

Table 3: Adjusted odds ratio 95% confidence intervals (95%CI) for Jidoka factors related to fatigue [a].

	Cases [b]	Controls [c]	95% CI	P
Sex				
Male	200	961	10.92(4.80-24.84)	<0.01
Female	69	192	1	
Age (years)				<0.01
<25	21	198	1	
25–34	69	340	1.72 (1.19–2.49)	
35–44	**91**	**287**	2.42 (1.68–3.50)	
45–54	53	288	2.64 (1.81–3.88)	
>54	35	117	3.44 (2.27–5.21)	
Economic activity				<0.01
Services	37	90	1	
Agriculture and	62	319	2.69 (1.91–3.79)	
fishing			0.94 (0.72–1.24)	
Industry	**103**	333	1.36 (1.05–1.76)	
Construction	67	**409**		

Job (5'S) Principles				<0.01
Usual	**254**	**1129**	1	
Atypical	14	24	2.08 (1.27–3.39)	
Workplace (5'S) Principles			<0.01	
Usual	**193**	**1026**	1	
Atypical	76	126	2.85 (2.27–3.59)	
Over Time Work shift hour				<0.01
<1.5 h	69	380	1	
1.5 – 2 h	**139**	**562**	1.25 (1.00–1.57)	
>2 h	61	209	1.44 (1.10–1.90)	
Type of contract of employment				
Permanent	113	449	1	<0.01
Temporary	**151**	**622**	5.18(2.63–10.18)	
Other	5	82	5.26 (2.67–10.35)	<0.01

a: Variables selected automatically backwards with the likelihood ratio criterion and further assessed with Wald test.
b: Cases: fatal occupational fatigue (FOF) (n = 269).
C: *Controls*: non-fatal occupational fatigue (NFOF) (n = 1153).

6 CONSTRUCT THE DOE FOR THE JIDOKA

The DOE depends on data mining for the idle time response value that appeared in "Table 1,2 and 3". The overtime allowable (30: 90 min), the Rest Time in shift (60:120 min), Temporary Laborers (10: 30), manual labor old years (35: 44 years) and Shift in Thursdays (300: 360 min). In our problem applied in 10th of Ramadan city, Ideal Standard international Co. for bathtubs. "Fig. 6" illustrates the overtime must less than or equal 30 min in day, the rest time not excess 1 hr, and working time in Thursday must not excess 6 hrs/shift and forbid manual work for labourers less 35 years ago, and no effect from temporary labor till 30 labourers.

Table 4: Design of DOE of Jidoka

Over-Time Allowab	Rest Time	Temporary Laborers	Manual L old years	Shift in Thursday	Idle Time
30:90 min	60:120 min	10:30 in same work place	35 : 44 years old	300 : 360 min	min
30	120	30	35	300	18.2
90	120	10	44	300	46.4
30	120	10	35	360	12.8
30	60	10	44	360	25.1
90	120	30	44	360	41.2
90	60	30	35	360	26.7
30	60	30	44	300	28.9
90	60	10	35	300	31.2

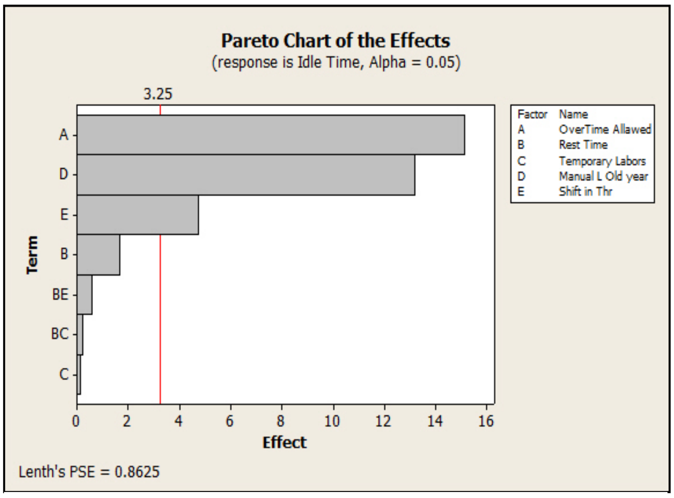

Fig 5: The significant factor of Jidoka Plan

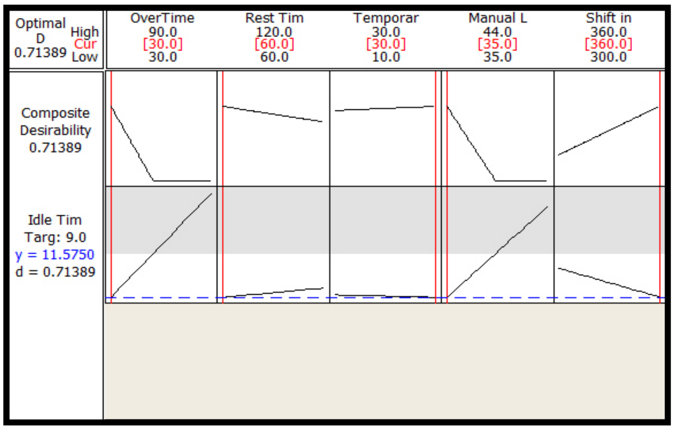

Figure 6: The optimum values of Jidoka factors

7 CONCLUSIONS

This paper is studying the causes that enforce of defects. The defects appear due to laborers mistakes that enlarge by wrong behaviours of Factories. The jidoka interests in determining the significant factors that must be adjusted to prevent the defects. The data mining dealing with the main results from this analysis show that the risk of a fatal consequence of occupational fatigue || idle times continuo increases with age and with work shift time, and is higher for male laborers, and for temporary laborers as compared with permanent laborers. Laborers in industry, construction, and job shop economic sectors are at higher risk too. Atypical jobs and workplaces are positive determinants of fatal outcome. Besides, main mechanisms related to fatal outcomes include strike and movable devices are frequently involved.

The study recommends that the permanent control of the behaviour of laborers in middle age, and reduce manual laborers, which cause 88% of the problems. As well as every 5 years for promotion and assignment of tasks associated with the previous tasks. The study also advises daily renewal in the nature of the work to prevent the 20% of the problems leading to occupational fatigue, because of boredom and excessive self-confidence, which generate 97% of the problems. And the employer not to be forced to extra time more than once an hour and there is strict control between the 1.00 pm and 2.00 pm, to avoid 50% of errors. In addition, increases the employer's good news and encouraging working or resting periods on Sunday and reduce the fitness muscles on the weekends of each week with the ideal arrangement for machinery and the application of the philosophies that reduce errors and reduce problems by 21% and 14% respectively. The main purpose of the research is to draw attention to annex the occupational fatigue to the list of waste, which dealt with Lean philosophy.

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