

## Interventions to Promote of Safety Participation Using Generalized Estimating Equations

IRAJ MOHAMMADFAM<sup>1</sup>; HOSSEIN MAHJUB<sup>2</sup>; OMID HAMIDI<sup>3</sup>; LEILI TAPAK<sup>2\*</sup>

<sup>1</sup>Department of Occupational Hygiene Engineering, School of Public Health and Research Center for Health Sciences, Hamadan University of Medical Sciences, Hamadan, Iran; <sup>2</sup>Department of Biostatistics and Epidemiology, School of Public Health and Research Center for Health Sciences, Hamadan University of Medical Sciences, Hamadan, Iran; <sup>3</sup>Department of Science, Hamadan University of Technology, Hamadan, Iran.

Received January 03, 2015; Revised April 04, 2015; Accepted June 14, 2015

This paper is available on-line at <http://ijoh.tums.ac.ir>

### ABSTRACT

Accidents and their resulting losses are one of the critical public health issues. Identification the near misses offer the opportunity to improve safety by developing effective prevention approach. The main objective of this study was to investigate the effects of two types of intervention in increasing the participation of first line managers in reporting near misses. In order to increase the participation, the Green Card System (GCS) was implemented. After preliminary studies, in order to increase the participation rate, the decision was taken to implement the intervention program. In this program, first line managers were divided into two groups. For the control group, the bonus was increased to double whereas, for the experimental group, in addition to the two-fold increasing remuneration (bonus), appropriate feedback and actions carried out in the context of reported near misses, were presented through regular collaborative meetings. The results showed that six months after the stop of the intervention, the rate of participation in both groups showed a significant increase. After 18 months of intervention, the participation trend in both groups was downward. However, this reduction was only significant in the control group. The findings highlight the long-term effects of the intervention of financial payments along with providing appropriate feedback.

**KEYWORDS:** *Accident, Near miss, Participation, Safety Culture*

### INTRODUCTION

Accidents and their harmful effects are one of the major problems of the health system. An occupational accident will temporarily and permanently disrupt the balance in the working environment in which it occurs. Altonen et al [1] have recognized 128 potential consequences of an accident, of which 70 impress only the business [1], and found accidents have about 20 actual outcomes. One of the most critical outcomes of occupational accidents is human ones. During the past years, estimates of occupational mortality have been made at the country level. The consequences of workrelated accidents show a considerable

economic burden to governments, employers and employees injured in working environment. Some studies estimate these indirect costs for organizations at several times the direct costs [2]. Preventing of work related accidents would seem to be a main ways of reducing costs related to unhealthy workplaces.

Detecting the before accident signals offers the opportunity to improve safety by developing effective prevention approach. The idea returned to near-miss events allow implementation more effective prevention approach. This is the basis of the notable "Learning From Experience", LFE paradigm [3].

Near misses in safety management have been identified as an important practice in the

\* **Corresponding Author: Leili Tapak**

Email: [tapak@umsha.ac.ir](mailto:tapak@umsha.ac.ir)

prevention of accidents [4]. In this context, it is necessary to gather information about events such as near misses which represents the possibility of accidents [5]. The concept of the accident pyramid has also been criticized [6]. Based on the accident pyramid for every major injury, there are about 30 minor injuries, 300 recordable injuries and 3000 near misses [7].

The importance of reporting near misses is still widely acknowledged. A positive correlation has been found between active reporting and improved safety performance [5].

Furthermore, using near misses helps strengthen the safety culture [8], especially when employers are motivated to participate in the process of identification and analysis of those events [9]. In fact, studies in the construction [10] and chemical industries [5] have shown that accident rate reduced by increasing the number of identified near misses. However, identifying near misses is not an easy task [9].

Whilst employment participation is recognized as an important element of a comprehensive approach to work safety, it is challenging to foster, with many barriers limiting the likelihood or capability of employment participation.

The barriers tight time schedule [11-12] lack of leadership [11, 13] lack of relevant skills and knowledge of employees recruited [11] adherence to one planning approach [11, 13] inappropriate program focus [11, 13-14] and evaluation [11, 13-14] as well as shortage of funds and resources [11, 14] are of significant constraints impairing community participation. Moreover, unsustainability [11, 13] failure to legislate and enforce appropriate rules [13] and fear of blame and punishment [15] deteriorate the situation even worse.

There are also some important inhibitory factors interrupting people's participation in reporting near-miss events [16] of which can be pointed out to potential recriminations for reporting (fear of disciplinary action, fear of peer teasing and investigation involvement concern), failure of motivational issues (lack of incentive and management discouraging near miss reporting) [16], lack of management commitment (sporadic emphasis and management fear of liability) [16], individual confusion (confusion as to what constitutes a near miss and how it should be reported), peer pressure (employees may feel pressure from colleagues not to report) and investigation style so that lengthy investigations that require employee participation may discourage reporting. Besides, direct disciplinary action concerning receiving a verbal warning, the potential addition of the incident to the employee's record, up to and including job dismissal, will discourage reporting. There are also some indirect

disciplinary actions playing an inhibitory role towards impaired participation in reporting near-miss events.

Safety participation is a mutual relationship where employers and their employees/employee representatives [17] can be able to share views, discuss issues and respect each other.

In this study safety participation involves helping co-workers, promoting the safety program within the workplace and putting effort into improving safety through observing, records, reports and controls of near misses.

The main objective of this study was to investigate the effects of two types of intervention in increasing the participation of first line managers in reporting near misses. This study was conducted in a steel Company, Iran. Based on the results of risk assessment, the main risks in the company are: Contact with electrical voltage, temperatures, indirect contact with sparks, contact with naked flames or with hot or burning objects or surroundings; falls, crash into a stationary object, struck by falling objects; Contact with sharp, pointed, rough or coarse elements, Acute overloads due to mechanical impact or influence.

## MATERIAL AND METHODS

In order to increase the participation of first line managers to report near misses, the Green Card System (GCS) was implemented. In this system, first line managers were encouraged to observe records, report near misses and to provide control plans through completing designed forms.

For this purpose, initially the first line managers received the necessary training about the importance of reporting and analyzing near-miss events, their role in prevention of major accidents, recognize them, report, and track. Then the special cards were first designed for line managers to record observed near-miss events along with reform proposals and cast them in the embedded boxes. The cards and boxes were readily available. Completed cards were collected weekly and were reviewed in the Safety Committee of the company. Finally, result of the decisions informed to the person completing the form.

After confirmation, the director was awarded \$ 2 to \$ 5 bonus per each completed form.

The participation rate increased in the first six months after implementation, then declined in the second six months. After preliminary studies, in order to increase the participation rate, the decision was taken to implement the intervention program. In this program, first line managers were divided into two groups: experimental (case) and control. For the control group, the bonus was increased to double whereas, for the experimental group, in addition to the two-fold increasing remuneration (bonus), appropriate feedback and actions carried out in the context of reported near misses, were

presented through regular collaborative meetings.

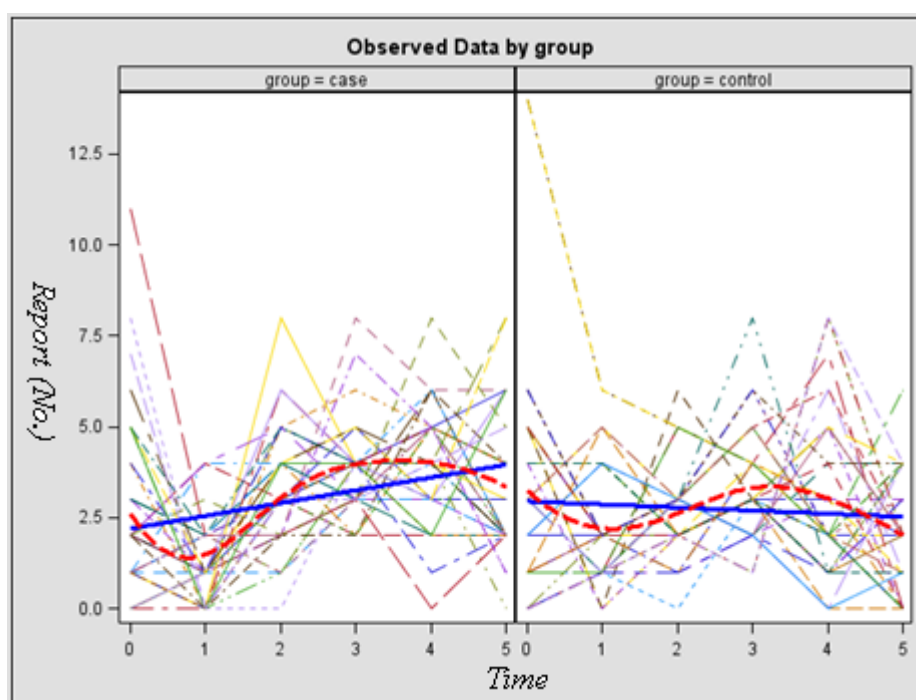
There were 75 first line managers participated in our study, of which 35 were cases and 40 were controls. The data were collected longitudinally. The count response variable was the number of near misses reported by first line managers at six-month intervals from the 2009 to the 2012. In addition, the independent variables of age, level of education, level of experience, and wages of first line managers have also been recorded.

With regard to the response variable (reported number of events) was measured for each of the six time points, therefore, we have used the

generalized estimating equations methods for analyzing longitudinal data. In order to perform multiple comparisons between time points, we used Fisher's protected test and a P significance level of 0.05 was chosen.

## RESULTS

Spaghetti plots for the reported number of events in six time points in case and control groups are shown in Figure 1. Population trend for the number of reported near misses is quite different in the two groups; the positive trend for cases and negative ones for controls.



**Figure 1.** Spaghetti plot for cases and controls

The average number of reported near misses, stratified by the group, is presented in Table 1. These clearly show the general effect of

time on reporting near misses, though the effect does seem to vary by group.

**Table 1.** Average of near miss reporting by first line managers at six-month intervals (values in parenthesis are standard errors)

Period	Year	Timepoint	Cases (NO.)	Controls (NO.)
Before the intervention	2009	First six months (T1)	2.66 (2.54)	3.25 (3.20)
		Second six months (T2)	1.29 (1.18)	2.20(1.62)
During the intervention	2010	First six months (T3)	3.29 (1.71)	2.58 (1.24)
		Second six months (T4)	3.92 (1.29)	3.40 (1.50)
After the intervention	2011	First six months (T5)	4.04 (1.63)	2.98 (2.26)
		Second six months (T6)	3.34 (1.94)	2.03 (1.60)

The mean change in reported near misses in two consecutive time points, along with their P-value is given in Table 2. In both groups, the number of reports is declined from time point 1 to time point 2. In addition, there is a significant increase from time point 2 to time point 3 and a

significant decrease from time point 5 to time point 6 in cases (*P* values in table). Besides, in the control group there is an increase from time point 3 to time point 4 and a reduction from time point 5 to time point 6.

**Table 2.** Comparison of time points

Group		T1-T2	T2-T3	T3-T4	T4-T5	T5-T6
Cases	Mean	1.371	-2.000	-0.633	-0.229	0.714
	P-value	0.005*	0.000*	0.043*	0.249	0.056
Controls	Mean	1.050	-0.375	-0.825	.425	0.950
	P-value	0.011*	0.104	0.002*	0.193	0.019*

\*Significant at 0.05

For these data, the number of reported near misses across time was modeled and GEE model for count response were fitted. The regressors include time (time coded 0, 1, 2, 3, 4 and 5 for the six time points), group (0, case; 1, control) and the interaction between time and group. Coefficient of the variables in GEE model along with standard errors and related P-values are presented in Table 3. Time variable had a significant effect on the number of reports

( $P=0.0093$ ). Positive coefficient means that the variable time has an incremental overall effect on the number of reports. In addition, the interaction between time and group was significant ( $P=0.0033$ ). This means that, the number of reports was different between cases and controls over time. Slope of the population trend line was  $0.0831 (=0.0831+0*-0.1346)$  for the case and  $-0.0515 (=0.0831+1*-0.1346)$  for controls which is in accordance with Figure 1.

**Table 3.** Analysis Of GEE Parameter Estimates (Empirical Standard Error Estimates)

Parameter	Estimate	Standard error	Pr >  Z
Intercept	0.8892	0.0913	<0.0001
Time	0.0831	0.0320	0.0093
Group	0.2557	0.1444	0.0767
Time*Group	-0.1346	0.0458	0.0033

In order to find the cause of this difference in slope between the two groups, the distribution of age, experience and payment variables were done for case and control group (Table 4). Distribution

of the three variables in cases and controls is different. As a result, in order to adjust the model, these variables were considered as independent variables in the model.

**Table 4.** Independent Samples Test

	Groups	Mean (S.E)	P-value
Age (yr)	Case	30.51 (4.32)	0.038
	Control	28.00 (5.75)	
Experience (yr)	Case	8.71 (4.94)	0.006
	Control	5.95 (3.16)	
Payment (\$)	Case	193.33 (45.08)	0.000
	Control	145.30.50 (28.64)	

By entering these variables in the model, two models were obtained separately for the two groups. Coefficient of the variables in GEE models along with standard errors and related P-values are presented in Table 5 for cases and controls. Accordingly, for both groups, time variable had a significant effect on the number of reports ( $P=0.0009$  for cases and  $P<0.0001$  for controls) but it was completely in two different directions. Positive coefficient in cases means that the variable time has an incremental effect on the number of reports, while in controls the negative coefficient represents a reduction in the number of reports over

time which is in accordance with Figure 1.

Moreover, the effect of payment variable on response variable was significant ( $P=0.0129$ ) in cases. The negative coefficient indicated a decreasing effect of this variable over time. However, in the control group, this variable had no significant effect on the response ( $P=0.1236$ ).

In addition, the education variable had a significant effect on the number of reports only for cases ( $P=0.0001$ ) with negative sign which means that in the fixed time points, first line managers with higher education have reported more near misses than others.

**Table 5.** Analysis Of GEE Parameter Estimates (Empirical Standard Error Estimates)

Parameter	Case			Control		
	Estimate	Standard Error	Pr >  Z	Estimate	Standard Error	Pr >  Z
Intercept	1.3981	0.2892	<0.0001	5.2176	1.8317	0.0044
Time	0.0909	0.0273	0.0009	-0.3057	0.0404	<0.0001
Age	0.0030	0.0070	0.6667	0.0099	0.0193	0.6065
Edu 1	-0.3652	0.0954	0.0001	-0.2868	0.3833	0.4543
Edu 2	0.0000	0.0000	.	0.0000	0.0000	.
Exp	-0.0081	0.0085	0.3452	-0.0248	0.0743	0.7386
Payment	-0.0008	0.0003	0.0129	-0.0071	0.0046	0.1236

In order to examine how well the model fits the observed sample proportions, the estimates from the GEE model was used to calculate the estimated number of reports across the six time

points for two groups. Figure 2 depicts this estimated average of counts and the observed averages. As can be seen from Figure 1, the model fit of the observed averages is reasonable.

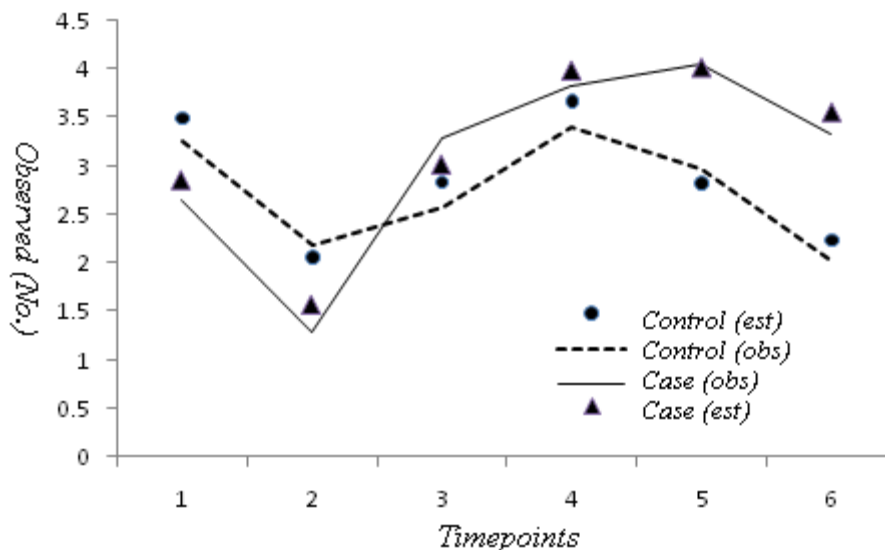


Figure 2. Observed number of reports and estimated number of reports across time

## DISCUSSION

The results showed that the implementation of GCS and analyzing the near misses cannot be successful alone. In this study it was found that the participation rate of first line managers in reporting near misses, after six months of implementing the GCS, has been declined. This finding is consistent with the findings of Fam and Nikoomaram [18].

Training the correct practices to employees and giving appropriate feedback seems to be an effective way of enhancing employee's participations [19]. To be fully effective, a participatory program requires that the team members have a suitable motivator and learn to act as their representatives [20]. The motivational factors that encourage staff to enter these types of awards are not fully understood. Preliminary research [21], suggest that achieving awards can be used to motivate the workforce, but being externally organized, they may serve a number of other functions as well. Incentive programs can improve organizational performance and motivate the Labors [21]. Schemes can be used in a variety of situations to improving health and safety performance [22]. Health and safety incentive schemes are usually internally organized programs that focus on employee participation. Typically, the employer awards some "prize" (e.g., cash, merchandise, travel voucher) to individual employees or employee groups who have worked for a specified period of time without having an

accident [23]. The evidence as to whether they are effective management tools is ambiguous [24].

Success may depend on choosing an appropriate scheme for the particular situation [24]. Incentive schemes are frequently encountered in the United States, and have been common in the United Kingdom for many years [25].

At the end of the intervention phase of the two groups, it was found that participation rates increased in both groups. However, this increase was significant only in the cases. These findings suggest that in the short term to provide appropriate feedback can lead to greater participation. These findings are consistent with previous studies [26-27].

Six months after the end of the intervention, the rate of participation in the reported near misses in both groups showed a significant increase. In other words, both types of intervention, i.e. the financial rewards and financial rewards associated with providing appropriate feedback in the medium term have increased participation. This finding indicates the effect of both rewarding method on increasing the participation rate. The results of Bailey et al. [28] and Smither et al. [29] studies confirm the role of different feedback on behavior change.

Twelve months after the intervention ended, participatory process was increased in cases. Over the 18 months of the intervention, the participation in this group was decreased, although this decrease was not significant.

The findings highlight the long-term effects of the intervention of financial payments along with providing appropriate feedback. In another study, Mohammadfam et al. [30] examined the impact of interventions to increase the participation of first line managers. The results of this study suggest that the impact of cooperative learning in the long term is more appropriate than the classical education [30].

Cooperative learning uses small groups that work together to form an interdependent link maximizing each group member's learning. It is supported by the theories of group dynamics and cooperation [31].

Cooperative learning is a skillfully constructed avenue for developing the finesse of working together. It has proven its strength with desirable outcomes in various areas of academic achievement [32], self-esteem and conflict management [33-34], increased motivation [34], and constructive interaction with partners [35].

In controls, 12 and 18 months after completion of the intervention, the participation rate was declined. This reduction was significant at 18 months. These findings indicate that financial incentives for participation could not be effective only in the long run.

The findings of this study referred to the effect of providing appropriate feedback for the managers to increase participation in the short term (immediately after the intervention program), medium term (6 and 12 months after the intervention program) and long term (18 months after the end intervention). These results are consistent with those of Mohammadfam et al. [30], and Gillat and Sulzer-Azaroff[36].

## CONCLUSION

Long-term monitoring of intervention and designing other interventions to increase the participation of line managers and the monitoring of their results is recommended for future studies.

## ACKNOWLEDGEMENTS

The authors would like to thank the managers and personnel of MABNA group for their co-operation. The authors declare that there is no conflict of interests.

## REFERENCES

1. Aaltonen MV, Erkki UR, Jorma S et al. The accident consequence tree method and its application by real-time data collection in the Finnish furniture industry. *Safety Sci* 1996; 23(1): 11-26.
2. Andreoni D. The cost of occupational accidents and diseases. No. 54. Intl Labour Organisation, 1986.
3. Dechy N, Yves D, Espen F et al. Results and lessons learned from the ESReDA's accident investigation working group: introducing article to "Safety Science" special issue on "Industrial Events Investigation". *Safety Sci* 2012; 50(6): 1380-1391.
4. van der Schaaf T, Kanse L. Biases in incident reporting databases: an empirical study in the chemical process industry. *Safety Sci* 2004; 42(1): 57-67.
5. Jones J, Playforth M. The effect of the introduction of NHS Direct on requests for telephone advice from an accident and emergency department. *Emerg Med J* 2001; 18(4): 300-301.
6. Salminen S, Tallberg T. Human errors in fatal and serious occupational accidents in Finland. *Ergonomics* 1996; 39 (7): 980-988.
7. Geller ES, Performance management and occupational safety. *J Organ Behav Manage* 1990; 11 (1): 149-174.
8. Cooper P. Towards a model of safety culture. *Safety Sci* 2000; 36 (2): 111-136.
9. Heron J, Reason P. A participatory inquiry paradigm. *Qual Inq* 1997; 3 (3): 274-294.
10. Howat P, Cross D, Hall M et al. Community participation in road safety: Barriers and enablers. *J Commun Health* 2001; 26 (4): 257-270.
11. Krieger J, Allen C, Cheadle A, Ciske S, Schier JK, Senturia K, Sullivan M. Using community-based participatory research to address social determinants of health: lessons learned from Seattle Partners for Healthy Communities. *Health Educ Behav* 2002; 29 (3): 361-382.
12. Kinney CF. Improving community health through collaboration. *Qual Prog* 1998; 31(2) 39.
13. Boyce TE, Geller E S. A Community-Wide Intervention to Improve Pedestrian Safety Guidelines for Institutionalizing Large-Scale Behavior Change. *Environ Behav* 2000; 32 (4): 502-520.
14. Hutchinson C, Lange I, Kanhonou L, Filippi V, Borchert M. Exploring the sustainability of obstetric near-miss case reviews: a qualitative study in the South of Benin. *Midwifery* 2010; 26(5): 537-543.
15. Phimister JR, Oktem U, Kleindorfer PR, Kunreuther H. Near miss incident management in the chemical process industry. *Risk Anal* 2003; 23 (3): 445-459.
16. Goraya A, Amyotte PR, Khan FI. An inherent safety-based incident investigation methodology. *Process Saf Prog* 2004; 23 (3): 197-205.
17. Neal A, Griffin MA, Hart PM. The impact of organizational climate on safety climate and individual behavior. *Safety Sci* 2000; 34 (1): 99-109.

18. Fam IM, Nikoomaram H, Soltanian A. Comparative analysis of creative and classic training methods in health, safety and environment (HSE) participation improvement. *J Loss Prevent Proc* 2012; 25(2): 250-253.
19. Mohrman SA, Ledford GE. The design and use of effective employee participation groups: Implications for human resource management. *Hum Resour Manage* 1985; 24 (4): 413-428.
20. Friend MA, Dunn AM, Jennings J. Lessons learnt about effectively applying participatory action research: a case study from the New South Wales dairy industry. *Anim Prod Sci* 2009; 49 (11): 1007-1014.
21. Walker D, Tait R. Health and safety management in small enterprises: an effective low cost approach. *Safety Sci* 2004; 42(1): 69-83.
22. Alonso A, Baker DP, Holtzman A, Day R, King H, Toomey L, Salas E. Reducing medical error in the military health system: how can team training help? *HUM RESOUR MANAGE R* 2006; 16.3: 396-415.
23. Goldberg AT. How many stitches are boots worth? The true effect of safety incentive programs. *Professional Safety* 1998. 43(7): p. 37.
24. Choi TN, Chan D W, Chan AP. Potential difficulties in applying the Pay for Safety Scheme (PFSS) in construction projects. *Accid Anal Prev* 2012; 48: 145-155.
25. Tait R, Walker D. Motivating the workforce: the value of external health and safety awards. *J Saf Res* 2001; 31(4), 243-251.
26. Clarke S, Ward K. The role of leader influence tactics and safety climate in engaging employees' safety participation. *Risk Anal* 2006; 26 (5): 1175-1185.
27. Humpel N, Owen N, Leslie E. Environmental factors associated with adults' participation in physical activity: a review. *Am J Prev Med* 2002; 22(3): 188-199.
28. Bailey C, Fletcher C. The impact of multiple source feedback on management development: Findings from a longitudinal study. *J Organ Behav Manage* 2002; 23 (7): 853-867.
29. Smither JW, London M, Reilly RR. Does Performance Improve Following Multisource Feedback? A Theoretical Model, Meta Analysis, And Review Of Empirical Findings. *Pers Psychol* 2005; 58 (1): 33-66.
30. Mohammadfam I, Kianfar A, Mahmoudi S, Mohammadfam F. An Intervention for the Promotion of Supervisor's Incidents Reporting Process: the Case of a Steel Company. *Int J Occ Hyg* 2011; 3(1): 18-22.
31. West SA, Pen I, Griffin AS. Cooperation and competition between relatives. *Science* 2002; 296(5565): 72-75.
32. Watson SB Marshall JE. Effects of cooperative incentives and heterogeneous arrangement on achievement and interaction of cooperative learning groups in a college life science course. *J Res Sci Teach* 1995; 32(3): 291-299.
33. Lazarowitz R, HERTZ-Lazarowitz R. Baird JH. Learning science in a cooperative setting: Academic achievement and affective outcomes. *J Res Sci Teach* 1994; 31 (10): 1121-1131.
34. Daniels R. Motivational mediators of cooperative learning. *Psychol Rep* 1994; 74 (3) 1011-1022.
35. Jang H, Reeve J, Deci EL. Engaging students in learning activities: It is not autonomy support or structure but autonomy support and structure. *J Educ Psychol* 2010; 102(3): 588.
36. Gillat A, Sulzer-Azaroff. Promoting principals' managerial involvement in instructional improvement. *J Appl Behav Anal* 1994; 27 (1): 115.