Continuous Monitoring of At-risk Behaviours: A Risk-based Statistical Control Method

D. Masi & P. Trucco
Politecnico di Milano, Milano, Italy

ABSTRACT: An effective implementation of the Behaviour-Based Safety approach requires a continuous monitoring of the performance of workers. However, this continuous monitoring is challenging for practitioners due to the great demand of time, cost, and professional skills needed for its implementation. This paper proposes a sustainable solution consisting in a method which combines the Continuous Safety Sampling Method, a statistical analysis of non-conforming observations, and a consistent experts' judgements elicitation process based on the Analytic Hierarchy Process.

1 INTRODUCTION

Accidents at work continue to be one of the major work environment challenges facing legislators, enterprises, and workers worldwide. According to the Labour Force Survey (LFS), using data from 2007, the 3.2% of the workforce in the EU-27 reported an accident at work in the past 12 months. This corresponds to approximately 6.9 million persons. In line, data from the European Statistics on Accidents at Work (ESAW) showed that 2.9% of the workers had an accident at work with more than three days of sickness absence and 5580 workers died in a fatal accident in 2007 (Eurostat European Commission. 2010). The data clearly show that accidents at work place a considerable burden on individuals, society and enterprises.

Because of the relevance of the problem, several attempts have been made aiming at improving Occupational Safety and Health (OSH) conditions within enterprises. In particular, several studies focused on the causes of accidents, with the purpose of removing these causes by means of different kinds of interventions. In this regard, there is scientific evidence that unsafe behaviours are a major cause of accidents (see e.g. Heinrich, 1950 and Hide et al, 2003); as a consequence, many approaches aiming at modifying human unsafe behaviours have been proposed in the scientific literature.

Among these, the Behaviour-Based Safety (BBS) approach is gaining an increasing attention in the area of OHS. BBS aims at modifying human unsafe behaviours (Scott Geller, E., 2001) by adding antecedents and/or consequences to the situation to alter response probability (DePasquale & Geller, 2000). Examples of interventions creating antecedents and consequences are Goal Setting and Feedback (DePasquale & Geller, 2000; Cameron & Duff, 2007). A goal of compliance level to safety is an antecedent which alters workers' response: the desire to achieve the goal would motivate workers to make efforts in this direction. On the other hand, positive feedback, incentive or reward are consequences which reinforce workers' safe behaviours.

Over the years, BBS has been applied successfully by many researchers in various settings such as clinical medicine (Dickerson et al., 2010), manufacturing (Hermann et al., 2010), mining (Hickman & Geller, 2003) and institution office (Al-Hemoud & Al-Asfoor, 2006). Moreover, BBS was found to be a promising way to further prevent accidents. Many researchers analysed the OSH records of enterprises which implemented BBS and the results revealed a significant decrease in incidents across groups following the BBS implementation (see e.g. Krause et al., 1999).

Despite these successful implementations, BBS approach faces a critical difficulty in achieving persistent effects. Some studies have reported that behavioural safety performance declined (Johnston et al., 1994; Lingard & Rowlinson, 1998) or even went back to the baseline level (Komaki et al., 1978) after intervention was stopped.

Although many factors may affect the final outcomes of BBS approach, this difficulty is largely attributed to the intervention strategy itself. Basically, BBS intervention focuses on external antecedent and consequence for the reinforcement of safe behaviours (Cameron & Duff, 2007), thus creating OHS improvements with a sensitive dependence on external situations. When the external situation changes, the safety performance is likely to deteriorate (DeJoy, 2005). As a consequence, a continuous monitoring of the external situation and of the performance of the workers is necessary.

However, this activity is challenging due to the great demand of time, cost and professional skills for its implementation. In the light of the relevance of this practitioners' challenge, this paper proposes a solution consisting in a method which combines three different techniques: the Continuous Safety Sampling Method (CCSM) (Quintana and Nair, 1997), a statistical analysis of non-conforming behaviours, and a consistent experts' judgements elicitation process based on the Analytic Hierarchy Process (AHP).

The paper is structured as follows. In paragraph 2, the CCSM is summarised, due to its relevance for the proposed model. In paragraph 3, the Risk-Based Statistical Control Method is presented, by means of its application in an Italian manufacturing enterprise. Finally, in paragraph 4 main conclusions are taken.

2 THE CONTINUOUS SAFETY SAMPLING METHODOLOGY

The CCSM (Quintana and Nair, 1997) represents a method for the continuous monitoring of the external situation and of the performance of the workers. The methodology aims at collecting information on the safety conditions in a statistically verifiable and economically viable manner by using the principles of work sampling and control charts. The hypothesis is that a random sample of a sufficiently large size, as in work sampling, reflects the state of the system being observed. Sampling aims at observing the occurrence of conditions that may become hazardous in a given system, called dendritics. On the other hand, by providing information regarding the tendency of a system, the control charts in CCSM indicate when systems tend to become hazardous, thus facilitating the implementation of corrective steps.

For the creation of CSSM five steps are necessary:

Step 1 - Dendritic construction. This step consists in the identification of the core conditions leading to hazards in any given system. This analysis can be performed by means of a Preliminary Hazard Analysis.

Step 2 - Random Sampling. The sampling can be performed in conjunction with other routine job functions, without additional allocation of resources.

Step 3 - Control chart. A p-chart is constructed by plotting the daily value of $\bar{p}$ against the date. The $\bar{p}$ is the daily weighted average of all the proportion of non-conforming observation. The Upper Control Limit (UCL) and the Lower Control Limit (LCL) are given by formulas reported in Equation (1) and in Equation (2):

$$UCL = \bar{p} + 3 \cdot \sqrt{\frac{\bar{p}\cdot(1-\bar{p})}{n}} \quad (1)$$

$$LCL = \bar{p} - 3 \cdot \sqrt{\frac{\bar{p}\cdot(1-\bar{p})}{n}} \quad (2)$$

Step 4. The control chart observations are tested for "out of control conditions".

Step 5. If an out of control condition is detected, appropriate action is taken to eliminate or control these conditions and thus to maintain a desired safe system.

The application of the above stepwise procedure provides a cost effective way of keeping a continuous check on the safety status of the workplace under consideration.

However, CCSM, in the described formulation, is not adequate for the continuous monitoring of the external situation and of the performance of the workers in a Behaviour-Based Safety perspective. The main limitation is that the model does not provide an estimation of the risk related to the non-conforming behaviours. The method distinguishes between conforming and non-conforming behaviours, without any further clarification on the criticality or on the expected consequences of the behaviours themselves. In fact, different at-risk behaviours are characterized by different criticalities.

When the OHS performance of the whole enterprise is monitored, interventions can be introduced only when the risk related to the non-conforming behaviours is not acceptable, while it is not possible to intervene every time that behaviours are simply non-conforming. If interventions implemented without any estimation of the criticality of the related non-conforming behaviours, resources can be easily wasted in correcting behaviours which are not critical for the improvement of the OSH performance of the enterprise.

In the light of the above, modifications and integrations to the CCSM are necessary for the continuous monitoring of the external situation and of the performance of the workers in a Behaviour-Based Safety perspective. This paper proposes a risk-based statistical control method which is grounded on the original CCSM and which overcomes its mentioned limitations by combining CCSM with a statistical analysis of non-conforming behaviours, and with a consistent experts' judgements elicitation process based on the Analytic Hierarchy Process (AHP).

The risk-based statistical control method re-defines some parameters proposed by CCSM, thus shifting the method from a simply non-conforming based method into a risk-based method. The method has been tested by means a pilot application in an Italian manufacturing company which produces tractors. The method, together with the results obtained during its empirical application, are presented in the following paragraph.

3 THE RISK-BASED STATISTICAL CONTROL METHOD

Coherently with the steps proposed by CCSM, for the creation of the model five steps are necessary, which consists in (1) Dendritic construction, (2) Random Sampling, (3) Control chart design (4) Test for "out of control conditions, and (5) Action.

Step 1. The dendritic construction consists in the identification of the core conditions leading to hazards in the system. A preliminary hazard analysis has been performed in the monitored enterprise, and a checklist of behaviours leading to hazards has been identified. The dendritics leading to hazards have been classified in different groups. These dendritics are reported in Table 1. Many of the identified dendritics are workers' behaviours; however, some dendritics more related to contextual aspects, such as obstacles not clearly indicated, have been included.

Table 1. Checklist of dendritics.

Machinery and Tools
D1 Tools are not correctly used
D2 Tools are not adequate or in non-adequate conditions
D3 Heavy objects are not ergonomically stored
D4 Materials are not ergonomically stored in cart lifts
PPEs
D5 Workers do not use protective gloves necessary for the task
D6 Workers do not use protective glasses necessary for the task
Procedures
D7 Procedures are not adequate
D8 Procedures are not known or not understood
D9 Procedures are not followed
D10 Lifting carriages are not correctly used
D11 Suspended loads are not correctly harnessed
D12 Forklifts are not used according to the procedures
D13 Forklifts stop close to pedestrian crossings
D14 Safety belt is not used
D15 Use of music earphones
Working environment
D16 Obstacles are not clearly indicated
D17 Floor and corridors are not clean
D18 Materials and tools are not stored in the special containers
D19 Lack of indications for the use of the tools
D20 Waste containers are full
D21 Lifting carriages are not correctly functioning
D22 Forklifts stop in forbidden areas
D23 Lockout procedures are not correctly followed
D24 Safety devices are not correctly used
D25 Lack of indications for the shelves

The contemporary assessment of behavioural and contextual conditions potentially determining accidents is one advantage of the model, which allows for an unique analysis of all the aspect that determine the OSH performance of the company. Each of the dendritics is assessed during the inspection, and 1 is used for the indication of non-conformity, while 0 is used to state conformity.

Step 2. The sampling can be performed in conjunction with other routine job functions, without additional allocation of resources. In the analysed enterprise, the sampling has been done by monitoring the safety conditions of the "Transmissions" department, during 19 work-shifts.

Step 3 - Control chart. The main modification introduced in the model consists in the way in which the control chart is designed. Instead of the p-chart proposed by CCSM, the model uses a R-chart, which means Risk-chart. A R-chart is constructed by plotting the daily value of $\bar{R}$ against the date. $\bar{R}$ is the daily weighted average of all the proportion of non-conforming Risks. The Upper Control Limit (UCL) and the Lower Control Limit (LCL) are given by the formulas reported in Equation (3) and in Equation (4)

$$UCL = \bar{R} + 3 \cdot \sqrt{\frac{\bar{R} \cdot (1-\bar{R})}{n}} \tag{3}$$

$$LCL = \bar{R} - 3 \cdot \sqrt{\frac{\bar{R} \cdot (1-\bar{R})}{n}} \tag{4}$$

Risk is defined as the product between the severity of consequences (D) and the probability of occurrence of the accident (E) and of its related causes C_k, as indicated in Equation (5).

$$R = D \cdot P(E, C_1, C_2, \dots, C_n) \tag{5}$$

The probability of occurrence of the accident and of its related causes can be calculated by means of Bayesian marginalisation, i.e. the summation of the products between the probability of occurrence of the accident, conditional to the occurrence of the k-cause $P(E/C_k)$, and the probability of occurrence of the cause $P^*(C_k)$, as indicated in Equation (6).

$$P(E, C_1, C_2, \dots, C_n) = \sum_{k=1}^{N} P(E/C_k) \cdot P^*(C_k) \tag{6}$$

It is important to underline that the first term $P(E/C_k)$ has to be estimated during the setting of the model, and it is kept constant in further observations, while the second term$P^*(C_k)$ is obtained by the daily observation of non-conforming dendritics.

The probability $P(E/C_k)$ can be easily estimated using the Bayes' theorem, as shown in Equation (7)

$$P(E/C_k) = \frac{P(C_k/E) \cdot P(E)}{P(C_k)} \tag{7}$$

In Equation (7), $P(C_k/E)$ indicates the probability that an accident occurs as the direct consequence of the occurrence of the k-cause; $P(E)$ indicates the probability of occurrence of the accident, and $P(C_k)$ indicates the prior estimation of the probability of occurrence of the k-cause. An estimation of these three terms is necessary.

The probability of occurrence of an accident $P(E)$ has to be estimated during the setting of the model, and kept constant in further observation. The historical value of $P(E)$ during the year t, called $P(E)_t$, can be estimated as ratio between the number of accidents happened during one year and the number of total worked hours. The actual value of $P(E)$ can be estimated by applying exponential smoothing to the historical values. In the analysed case, the historical values of the last three years have been used; these values are reported in Table 2. Exponential smoothing (Equation 8) has been applied to the historical values $P(E)_t$ reported in Table 2.

$$S_t = P(E)_t + (1-\alpha) \cdot S_{t-1} \quad (8)$$

In Equation (8), the initial value of the S_1 has been calculated as value of the first year, and the parameter alpha has been set to 0,9 in order to give higher importance to the most recent data. Indeed, the interventions progressively implemented improve the OHS conditions of the enterprise, and it is possible to predict that this trend is ongoing. The final estimation, calculated with exponential smoothing, is P(E)=0,39

Table 2. P(E) calculated for the last three years.

Year	*Accidents*	$P(E)_t$
1	117	0,53
2	96	0,44
3	84	0,38

The initial estimation of the probability of occurrence of the k-cause $P(C_k)$ has been calculated as ratio between non-conforming observations and total observations during five working shifts. Some representative values of $P(C_k)$, with the relative number of non-conforming observation, are reported in Table 3.

$P(C_k/E)$, namely the probability that the k-cause will generate an accident, has been estimated by combining an estimation from historical data $P(C_k/E)_t$ and experts' judgments $P(C_k/E)_{AHP}$.

As for the estimation from historical data $P(C_k/E)_t$, coherently with the technique used for the estimation of $P(E)$, the data of the last three years have been used. $P(C_k/E)_t$ has been estimated as ratio between the occurrences of accidents generated by the k-cause $\#(E/C_k)_t$ of the considered year and the total number of accidents of the considered year $\#\, accidents_t$. This ratio is shown in equation (9).

$$P(C_k/E)_t = \frac{\#(E/C_k)_t}{\#\, accidents_t} \quad (9)$$

Table 3. Examples of values of $P(C_k)$.

Dedritics	Non-conf. obs.	Total obs.	$P(C_k)$
Tools are not correctly used	3	224	0,01
Tools are not adequate or in non-adequate conditions	6	224	0,03

On the other hand, experts' judgments $P(C_k/E)_{AHP}$ has been obtained using the Analytic Hierarchy Process (Saaty, 2008). The Analytic Hierarchy Process (AHP) is a theory of measurement through pairwise comparisons and relies on the judgements of experts to derive priority scales. It is these scales that measure intangibles in relative terms. The comparisons are made using a scale of absolute judgements that represents, how much more, one element dominates another with respect to a given attribute. Five experts were interviewed: the production engineer, the technology development engineer, the safety engineer, the safety manager, and the responsible for workshop machining. The experts were asked to pairwise evaluate the k causes by means of the following question: "Which of the two causes has the higher probability of generating an accident?". The results consists in a set of weights related to the k-causes of accidents.

The estimation from experts' judgments $P(C_k/E)_{AHP}$ and the estimation from historical data $P(C_k/E)_t$ have been mediated when possible. Indeed, the historical data did not contain any reference to some of the k-causes. For these k-casues, the final estimation $P(C_k/E)$ is equal to the estimation collected through experts' judgments $P(C_k/E)_{AHP}$. Some examples of final estimations are reported in Table 4.

Table 4. Examples of estimation of $P(C_k/E)$.

Dedritics	$P(C_k/E)_{AHP}$	$P(C_k/E)_t$	$P(C_k/E)$
Tools are not correctly used	0,08	-	0,08
Tools are not adequate or in non-adequate conditions	0,09	0,07	0,08

Having estimated all the terms necessary to the estimation of the probability $P(E/C_k)$, the last parameter estimated is the severity of consequences (D). Again, the historical value of D during the year t, called D_t, can be estimated as ratio between the number of work shifts lost because of accidents and the total number of working hours, multiplied by 1000, as reported in equation (10).

$$D_t = \frac{\#\, work\ shifts\ lost}{\#\, working\ hour} \cdot 1000 \quad (10)$$

The actual value of D can be estimated by applying exponential smoothing to the historical values. Also in this case, the simple exponential smoothing has been used with data of the last three years. Alpha has been set to 0,9 since the hypothesis is that OHS interventions implemented in the last years progressively reduce the number of injuries and that this positive trend will continue in the future. The historical values D_t are reported in Table 5.

Table 5. Data used for the estimation of D by exponential smoothing.

Year	D_t
1	1,03
2	1,06
3	0,96

The application of an exponential smoothing with alpha=0,9 gives a final value of D equal at 0,97.

Having estimated all the terms of Equation (7), it is now possible to calculate the criticality of the k-cause. The criticality is defined by Equation 11.

$$Criticality_k = D \cdot P(E/C_k) \qquad (11)$$

The criticality calculated for some of the k-causes is reported in Table (6).

Table 6. Criticality calculated for some of the k-causes.

Dedritics	P(Ck/E)	P(E)	P(Ck)	Criti-cality
D1 Tools are not correctly used	0,08	0,39	0,013	2,14
D2 Tools are not adequate or in non-adequate conditions	0,09	0,39	0,027	1,31
D3 Heavy objects are not ergonomically stored	0,05	0,39	0,009	1,94
D4 Materials are not ergonomically stored in cart lifts	0,04	0,39	0	0

The criticality is used for weighting the estimations of $P^*(C_k)$ obtained by the day-by-day observed non-conforming dendritics.

Having estimated all the terms of Equation (5), it is possible to calculate the total Risk of a production department, unit or single workplace. Some examples of numerical values of Risk are reported in Table 7.

Table 7. Risk of the department.

	D1	D2	D3	…	D24	
Critic.	2,14	1,31	1,94	…	0,00	Risk
Day 1	0	0	0	….	0	0,01587
Day 2	0	0	0,003	…	0	0,01507
Day 3	0	0	0	…	0	0,01456
Day 4	0	0	0	…	0	0,00482

The internal elements of Table (7) are the estimations of $P^*(C_k)$ obtained as ratio between the number of non-conforming observations and the total number of observations at each sampling session. For instance, the value 0,003, obtained in the sampling session of the day 2 for the cause "Heavy objects are not ergonomically stored", has been obtained as ratio between the number of non-conforming observations for "Heavy objects are not ergonomically stored" in the sampling session of the Day 2 (1 non-conforming observation) and the total number of observation in that day 2 (341 total observations).

In order to create the control chart, it is finally necessary to estimate the average R (equation 12), the Upper Control Limit (UCL) (equation 13), and the Lower Control Limit (LCL). In order to simplify the model, the lower control limit has been set to zero.

$$\bar{R} = \sum_t \frac{R_t}{t} \qquad (12)$$

$$LCS = \bar{R} + 3 \cdot \sqrt{\frac{\bar{R} \cdot (1-\bar{R})}{n}} \qquad (13)$$

In Equation (13) n is the number of observations at each sampling session whereas in Equation (12) t the number of periods.

Having estimated all the parameters, it is now possible to create the final control chart, as shown in Figure 1.

Step 4. The control chart shows that the risk level has been out of control in one case. An analysis of the out of control case showed that it was created by the synergic combination of different causes. In the analysed enterprise, the sampling has been done by monitoring the safety conditions of the "Transmissions" department, during 19 work-shifts.

Step 5. Interventions have been introduced to remove these causes.

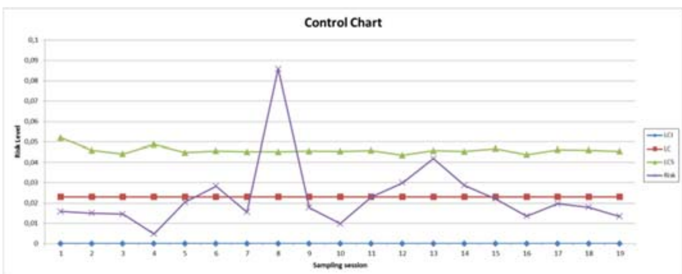

Figure 1. Control chart.

Further analyses show that the department does not present particular criticalities. The non-conforming observations are mainly related to a restricted set of causes, with a prevalence of

- Lockout procedures not correctly followed (D23)
- Workers do not use protective glasses necessary for the task (D6)
- Safety belt is not used (D14)
- Forklifts stop in forbidden areas (D22)
- Use of music earphones (D15)

The frequency of occurrence of each single cause is reported in Figure 2, while the cumulative risk curve is reported in Figure 3.

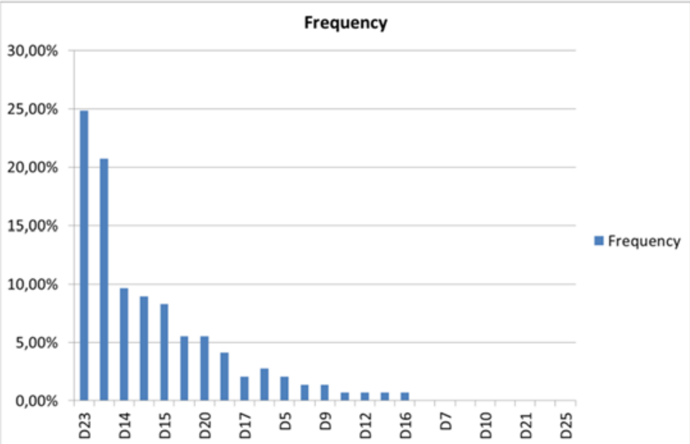

Figure 2. Frequency of occurrence of the k-causes.

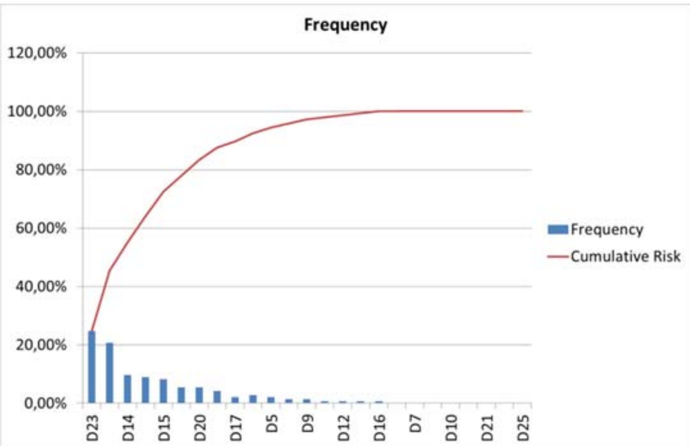

Figure 3. Cumulative risk curve

4 CONCLUSIONS

The proposed method allows the continuous monitoring of OHS conditions in workplaces associated to workers' safety performance. The combination of a checklist of dendritics and a control chart seems to be an adequate and sustainable approach for this purpose. On the one hand, the checklist, developed by mean of a Preliminary Hazard Analysis, includes all the hazardous conditions of the company and in particular all the at-risk behaviours. On the other hand, the control chart allows identifying all the hazardous conditions that are critical for the employees.

This is a first innovative aspect respect to the simple CCSM method. While CCSM gives the same importance to all the detected non-conforming behaviours, our method introduces a distinction based on the criticality of the specific non-conforming observation. A second innovative aspect of the method is related to the possibility of combining historical data and experts' judgments in the estimation of the criticality. This aspect is of paramount importance, since the external conditions, which influence workers' behaviours, change dynamically; experts' judgment is essential for a sound assessment of the dynamic evolution of the system.

Summing up, CCSM does not provide an estimation of the severity of the consequences related to the non-conforming behaviours, while traditional risk assessment does not allow continuous monitoring of working conditions and of the performance of the workers. The proposed method overcomes these limitations of CCSM and of risk assessment by combining their advantages. Being risk-based, the method allows for the estimation of the severity of consequences related to the non-conforming behaviours; on the other hand, thanks to statistical analysis of observed non-conformities, the method allows for the continuous monitoring of the external situation and of the performance of the workers, with an affordable demand of time, cost and professional skills for its implementation. Despite the implementation of our method requires an initial investment of resources that is higher than basic CCSM, the effort needed for its daily implementation is comparable. However, the former is substantially covered by the traditional risk assessment process (e.g. by using Job Safety Analysis or Facility Hazard Analysis), which is performed in each company (generally required by law).

The proposed method has some limitations, which open room for future improvements. The main limitation is related to the estimation of the severity factor (D). For the sake of simplicity, a single point severity value has been used for all the at-risk behaviours. However, a more robust estimation should consider different severities for different causes. Again, this estimation could be done by combining historical data, when available, with experts' judgments. A further limitation is related to the effectiveness of the model; it should be tested by means of a long term pilot implementation to check for any positive correlation between safety performance trends and the implementation maturity of the proposed method . This means that after the implementation of the method, a test should verify that the number of non-conforming behaviours as well as the related risk level reduced over time.

Finally, the model has been implemented at shop floor level (i.e. a Transmissions assembly department). Future researches could consider an extension of the method to be applied in other workplaces of a gneric industrial or service company. This requires a more flexible checklist as well as a clear definition of the sampling criteria that must be applied.

5 REFERENCES

Al-Hemoud, A.M. & Al-Asfoor, M.M. 2006. A behavior based safety approach at a Kuwait research institution. *Journal of safety research* 37(2): 201-206.

Cameron, I. & Duff, R. 2007. A critical review of safety initiatives using goal setting and feedback. *Construction Management and Economics* 25(5): 495-508.

DeJoy, D. M. 2005. Behavior change versus culture change: Divergent approaches to managing workplace safety. *Safety Science* 43(2): 105-129.

DePasquale, J. P. & Geller, E. S. 2000. Critical success factors for behavior-based safety: A study of twenty industry-wide applications. *Journal of Safety Research* 30(4): 237-249.

Dickerson, J.M., Koch, B.L., Adams, J.M., Goodfriend, M.A. & Donnelly, L.F. 2010. Safety coaches in radiology: decreasing human error and minimizing patient harm. *Pediatric radiology* 40(9): 1545-1551.

Eurostat European Commission 2010. *Health and safety at work in Europe (1999-2007) - A statistical portrait*.

Heinrich, H. W., Petersen, D. & Roos, N. 1950. *Industrial accident prevention*. New York: McGraw-Hill.

Hermann, J.A., Ibarra, G.V., & Hopkins, B.L. 2010. A safety program that integrated behavior-based safety and traditional safety methods and its effects on injury rates of manufacturing workers. *Journal of Organizational Behavior Management* 30(1): 6-25.

Hickman, J.S. & Geller, E.S. 2003. A safety self-management intervention for mining operations. *Journal of Safety Research* 34(3): 299-308.

Hide, S., Atkinson, S., Pavitt, T.C., Haslam, R., Gibb, A.G. & Gyi, D.E. 2003. *Causal factors in construction accidents*. Health and Safety Executive.

Johnston, J.J., Hendricks, S.A. & Fike, J.M. 1994. Effectiveness of behavioral safety belt interventions. *Accident Analysis & Prevention* 26(3): 315-323.

Komaki, J., Barwick, K.D. & Scott, L.R. 1978. A behavioral approach to occupational safety: pinpointing and reinforcing safe performance in a food manufacturing plant. *Journal of applied Psychology* 63(4): 434.

Krause, T.R., Seymour, K.J. & Sloat, K.C.M. 1999. Long-term evaluation of a behavior-based method for improving safety performance: a meta-analysis of 73 interrupted time-series replications. *Safety Science* 32(1): 1-18.

Lingard, H., & Rowlinson, S. 1998. Behavior-based safety management in Hong Kong's construction industry. Journal of Safety Research 28(4): 243-256.

Quintana, R., & Nair, A. (1996). Continuous Safety Sampling Methodology. *International journal of occupational safety and ergonomics: JOSE* 3(1-2): 3-14.

Saaty, T. L. 2008. Decision making with the analytic hierarchy process. *International journal of services sciences* 1(1): 83-98.

Scott Geller, E. 2001. Behavior-based safety in industry: Realizing the large-scale potential of psychology to promote human welfare. *Applied and Preventive Psychology* 10(2): 87-105.