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Measuring the effectiveness of a near-miss management system: An application in an automotive firm supplier

S. Andriulo, M.G. Gnoni *

Department of Innovation Engineering, University of Salento, Campus Ecotekene, Via Per Monteroni, Lecce, Italy

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ABSTRACT

Accidents and near-miss events are usually characterized by common causes and different consequences; a near-miss event is a potential hazardous condition where the accident sequence was interrupted; these events have common causes with accidents (or injuries), but, differently from the latters near miss consequences are null (or reduced).

Thus, near-miss events are accident precursors; furthermore, they provide "weak signals" to safety managers for preventing more effectively injuries at workplace. The study proposes a methodological framework to verify the global effectiveness of a near-miss management system (NMS): the model is based on lean safety and learning loops strategies. The proposed framework uses data collected by the firm NMS crossed with information extracted from occurred accidents/injuries. A case study in an automotive firm supplier is proposed aiming to validate the proposed framework. The analysis has revealed effective to outline overall potentialities of the proposed approach together with improvement points for the firm NMS application.

1. Introduction

Near miss events differ from accidents (or injuries) as the accident chain has been interrupted by such a condition: on the other hand, near miss events and accidents are usually based on common causes. Near miss events are defined as a hazardous situation where the event sequence could lead to an accident if it had not been interrupted by a planned intervention or by a random event [14,25,20,24,29]. Thus, near miss events are also defined as accident precursors as they outline potential causes leading to an accident before a real accident happens. Past and recent studies have outlined the importance of analyzing accident precursor events even if their analysis requires a higher effort than accidents and/or injuries [13,1,33,17] as their number is usually higher than one due to real accidents. On the other hand, analyzing accident precursors could provide the development of more effective prevention strategies, as accidents and precursor events are usually characterized by common causes: thus, it allows to identify deficiencies before accidents occur. Accident precursors represent a relevant source of knowledge for increasing safety levels in an organization as they point out lacks in safety system – the so called "weak signals" – without causing high consequences [19,21,23,8,34]. Monitoring "weak signals" and analyzing their causes will lead to prevent accidents in a more effective way.

The near-miss management system (NMS) developed by a company is the organizational tool for reporting and analyzing accident precursor in a firm in order to outline effective prevention programs for increasing its occupational safety levels [18,9]. NMSs have been also introduced in the OHSAS 18001 standard ([2]) as a relevant tool for the firm safety management system.

Although measuring performance of the safety management system is not a new issue, measuring the effectiveness of a NMS is relatively new. Few recent studies [15,6] have proposed a cross analysis between injuries and near-misses in a high risk sector (the oil industry) based on data derived from large databases; a structured approach for analyzing data derived directly from the field (e.g. a specific firm) has not been yet suggested. The aim of this study is to propose and validate a general framework for measuring the effectiveness of a NMS. Based on a proactive approach, the starting point will be the main features usually characterizing near-miss events such as the knowledge provided for preventing accidents. Thus, the proposed model will use a cross analysis between accident precursors and injuries recorded at a workplace to provide information for monitoring the effectiveness of a NMS. A case study about an automotive firm supplier applying lean safety strategies is discussed. The paper has been organized as follows: the general framework for measuring performance of a NMS system is described in detail in Section 2;

* Corresponding author. Tel.: +39 832297366.
E-mail address: mariagrazia.gnoni@unisalento.it (M.G. Gnoni).

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a case study is analyzed in Section 3 in order to validate the proposed approach, and results obtained are finally discussed.

2. Measuring effectiveness of a near miss management system in a manufacturing firm

NMSs are widespread since several years in industrial contexts characterized by high risk levels, such as chemical and petrochemical sectors [30,27,16]: few recent applications are developing in other industrial sectors – such as the manufacturing [10] – where the NMS design and application have to be integrated with different approaches, such as lean safety. According to lean thinking approaches, greater importance is assigned to the performance measurement process to outline improvement points in such a field of analysis; thus, lean safety approaches are mainly focused on learning by experience models. In brief, the lean safety approach – which is derived from the more wide strategy of lean thinking – is based on the well-known Deming continuous improvement cycle, i.e. the plan-do-check-act cycle. Furthermore, the "personal responsibility" concept is emphasized in lean safety approaches than in traditional ones: each employee contributes according to its own competence to improve performance; employers at all firm levels are directly involved to apply continuous improvement process as it is the most important fiat target. This strategy forced the application of an innovative safety culture and tools where workers are involved directly in monitoring and improving safety levels at workplace by a bottom up approach. Thus, lean safety approaches aim to minimize occupational risks, by boosting firm performances through continuous learning from the past experiences as well as effective benchmarking processes [11]. Applying a continuous improvement approach to safety management allows to develop proactive programs, rather than just to be compliance to such legislative requirement.

NMSs represent effective tools for applying lean safety approaches in a firm as they provide both employer engagement in improving safety levels and an updated "knowledge" from the operational field about actual safety levels at workplace. On the other hand, designing and managing NMS according to a lean safety approach requires new approaches [9].

By adopting the Deming cycle for designing and managing a NMS in a firm, four main steps could be outlined as depicted in Fig. 1: the first two refer to the NMS design and its application based on specific features regarding the industrial sector; next, the check phase has to be developed in order to evaluate if a following re-design action or a continuous improvement policy has to be applied. This model allows to design and manage NMSs based on learning loops, which are pillars of an effective safety management systems.

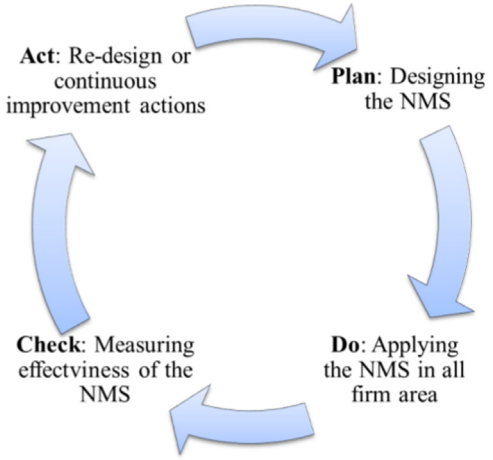

Fig. 1. The Deming cycle applied for NMSs.

Thus, the focus of the proposed study is to evaluate a reference framework for measuring the actual effectiveness of a NMS as an important source for preventing occupational accidents at workplace.

Based on common issues characterizing the near-miss literature, two main questions could be outlined as "performance indicators" of the NMS effectiveness:

Question 1. *Is the NMS reporting process quantitatively effective*?

Several consolidated studies – starting from the well-known Heinrich pyramid [13] to most recent ones [4,17] – outline that the total number of reported accident precursor events are usually higher than the total number of observed injuries. Thus, a first quantitative "metric" for measuring how workers are involved in the reporting process could be a comparison between the total number of events reported versus the occurred number of injuries/accidents in a specific time window.

Question 2. *Is the NMS reporting process qualitatively effective?*

Accident precursors are weak signals providing knowledge for preventing injury or damage; they are often characterized by common causes [19,18,21,33,23,22]. Furthermore, similarly to the root cause analysis carried out for accidents/injuries occurred at workplace [12,26,5], analyzing accident precursor events could contribute to increase the "Learning From Experience" approach of the firm. Thus, investigating if such a common causal factor could be outlined between precursor and injury events is a way for "measuring" the efficacy characterizing the reporting process. Furthermore, this analysis of precursor events will provide updated information about most widespread risk sources outlined directly by employers: this knowledge will allow the safety managers to address more effective interventions in their own safety management system.

Based on these issues, a framework for analyzing performance of a NMS is depicted in Fig. 2.

The process starts from outlining each single firm area, which could be equal to the shop floor organization.

Next, the main purpose is to verify the distribution of both precursor and injury/accident events in each plant area. Two indexes, defined as Precursor and Accident Index, have been introduced aiming to normalize the number of events according to the actual number of workers in each department. The Precursor Index (PI) for the *i*th department is defined in Eq. (1)

$$\text{Precursor Index}_i = \left(\frac{\text{NM}+\text{UA}+\text{UC}}{N_{\text{EMP}}}\right)_i \quad i = 1, \ldots, 10 \tag{1}$$

where NM, UA, and UC are the total number reported of near-miss events, unsafe acts and conditions, respectively; the N_{EMP} represents the total number of workers.

The Accident Index (AI) for the *k*th department is defined in the following equation:

$$\text{Accident Index}_i = \left(\frac{\text{IN}}{N_{\text{EMP}}}\right)_i \quad i = 1, \ldots, 10 \tag{2}$$

where IN is the total reported number of injuries occurred in the *i*th department in the time period. Based on firm internal procedures, IN could be evaluated by adding only the total number of hospitalized injuries or, otherwise, also non-hospitalized injuries could be added in the factor evaluation.

After index estimation for each plant area, a quantitative comparison between AI and PI values will be carried out: if the PI value is greater than AI, a first positive feedback about the NMS reporting process could be outlined as obtained results (expressed in terms of