Reflection on a model of accident reporting to help to implement efficient prevention strategies

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Abstract - *In our modern societies, socio-technological systems and human system interactions are taking on a large part in numerous domains such as health, control of risk, people safety, communication, information technologies, and so on. In order to manage such systems, it is necessary to put in place the most relevant actions and indicators. To facilitate decision making in various fields, such as people safety and risk management, the use of appropriate model and the definition of indicators are needed in order to deliver the relevant action plan especially to control occupational accidents.*

The aim of the article is to present our approach to analyze the classical Heinrich's model of occupational accidents and the classical safety indicator based on conventional frequency rate of lost time accident. Then we demonstrate their limits in order to define efficient prevention strategies.

Keywords: Accident modeling, safety indicator, prevention, complex system, risk management.

1 Introduction

Statistics from International Labor Organization and Worldwide Health Organization [1] put in evidence that 2 million occupational fatalities occur each year worldwide (e.g. around 1 fatality every 20 seconds) divided in 1.7 million due to occupational diseases and 0.3 million due to occupational accidents (plus 268 million lost time accidents more than 3 days out of work). To compare with, there were 2 million killed soldiers each year during the First World War that is to say as many as killed workers each year worldwide. Furthermore, to compare with these 2 000 000 fatalities we can remind other worldwide figures:

- 999 000 fatalities on the road (~ 1 million).
- 563 000 fatalities due to violence (~ 1/2 million).
- 502 000 fatalities due to war (~ 1/2 million).
- 312 000 fatalities due to VIH/Aids (~ 1/3 million).

Beyond all human and ethical issues, the economic impact of fatalities at work, estimated to 1 250 billion dollars (e.g. 4 % of worldwide GNP[1]), is quite huge. Behind global figures, we can find several situations worldwide. For instance, occupational fatalities are around: 5 500 in the USA, 100 000 in China, 6 000 in Russia and 40 000 in South America. It is still far too much. In order to prevent occupational accidents, most companies throughout the world are using prevention strategies. These strategies are based on model of accident [2] and safety indicator [3].

2 Model of accident and Safety indicator

Companies, that want to prevent accidents, often implement action plans based on Heinrich model and safety indicator referring to conventional frequency rate.

2.1 The Heinrich model of accident

Companies often use the Heinrich model whatever their activities. From 1930, in the occupational accidents prevention framework, the founding works of Heinrich [4] are often cited to illustrate a linear relationship between indicators, such as the accident frequency and accident gravity rates.

On 5 000 cases analyzed, Heinrich considered that a total of 330 accidents could divide into three categories: 1 major injury, 29 minor injuries and 300 nearmiss incidents. The relation 1-29-300 is often represented as a pyramid (Figure 1). Heinrich specified the scope and the limits of its study. In its book « Industrial accident prevention » McGraw-Hill 1959 (4th edition), Heinrich wrote at chapter « How the 300-29-1 Ratio Was determined »: «The determination of this no-injury accident frequency followed a study of over 5000 cases. The difficulties can readily be imagined. There were a few data existing on minor injuries to say nothing of no-injury accidents ».

However, the analyzed activities concerned rather «mechanical aspects », corresponding to workshops of the time that is in the 1930's the stakeholders are directly linked (linear aspect) to machines and tools.

[1] Gross National Product

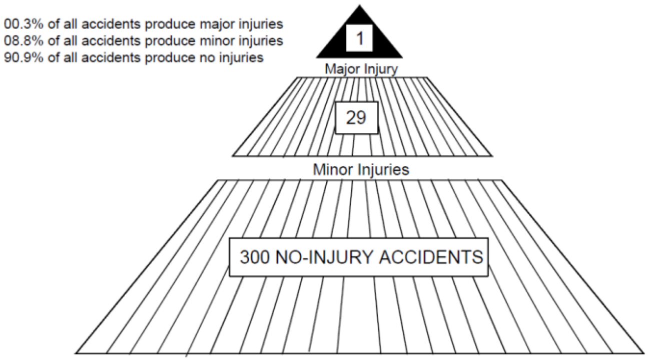

Figure 1 : The Foundation of a Major Injury. Source: H. W. Heinrich, Industrial Accident Prevention, 1950

Heinrich defined the accident as an « uncontrolled event » [4]:

> « Accident prevention is both science and art. It represents, above all other things, control - control of man performance, machine performance, and physical environment ».

Consequently, this work should not be « deny », but we have to merely revisit our practices according to new knowledges in order to apply them to activities whose the complexity level is considerably increased over the years. We have to act wisely to manage these shifts within organizations which are accustomed to use some methods of work and analysis.

However, we can ask these questions: this model has been studied specifically within mechanical workshops in the 1930's and used, is it suitable for any type of organization and activity which currently are increasingly often complex ?
Is it adapted to manage rare events with a major gravity?

2.2 Safety indicator: conventional frequency rate

The control of prevention strategies often relies from Heinrich model on the management of accident frequency rate.

The Heinrich model claims two basic relationships: first of all, both severity and frequency are inversely related and the second one is reductions in minor injuries will contribute in proportionate reductions in major injuries.

Accordingly, the hypothesis is if we work on the pyramid basis, any type of major accidents could be avoided. This reflection supposes that most accidents have common root causes and that minor injuries have the same potential to become serious. Thus, by preventing minor injuries, we will prevent serious injuries.

Nevertheless, this hypothesis can be only confirm or infirm by knowing the number and the type of accidents within an organization. For this, one of used indicator is the Conventional Frequency Rate (CFR).

The Conventional Frequency Rate allows measuring the number of lost time accidents over a period of time per million worked hours. The CFR is the number of lost time accidents over one day over a period of 12 months in general, per million worked hours. The CFR is defined by the ratio:

$$\mathrm{CFR} = \frac{\mathrm{LTA.10^6}}{\mathrm{NWH}}$$

With CFR: Conventional Frequency Rate, LTA: number of lost time accident and NWH: number of worked hours[2].

Another indicator is the Severity Rate (SR):

$$\mathrm{SR} = \frac{\mathrm{LD.10^3}}{\mathrm{NWH}}$$

With LD: number of days lost

Using this indicator is not as simple. It is possible to determine the sensitivity factor of CFR versus the size of the sample of people (Table 1). The graph on Figure 2 determines the impact factor of on lost time accident when the sample is varying between 1 and 5 000.

Sample	Impact factor
1	613,4969325
2	306,7484663
5	122,6993865
10	61,34969325
50	12,26993865
100	6,134969325
500	1,226993865
1 000	0,613496933
5 000	0,122699387

Table 1: Sensitivity factor versus the size of the sample

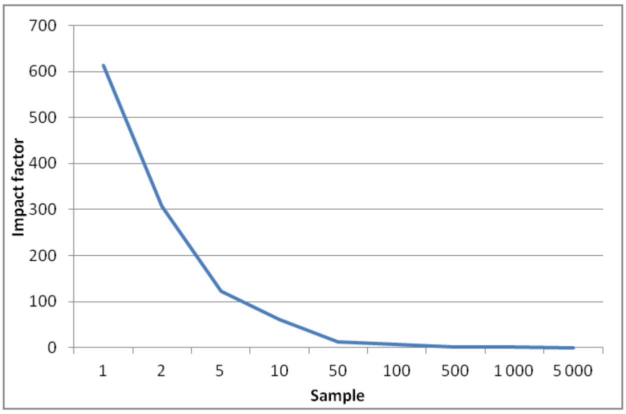

Figure 2: Indicator of result or follow up [3]

[2] The number of worked hours is calculated by multiplying the number of workers with the average annual working hours of a full time employee.

The moment when an accident occurs on the time horizon (usually 12 months) can also have an impact. Let us take an example where a plant has got one accident over a 12 months period. If the accident is occurring in January:

- The CFR[3] in January is 12 times higher than it will be at the end of December.
- The cumulative CFR will be impacted all the yearlong.

If the accident occurs in December, between January and the end of November, the indicator will be equal to zero with a « feeling » to control risks.
In December, the indicator will turn red with the feeling that suddenly the situation was worsen, e.g. before the accident everything seems ok and after the accident everything seems bad.

2.3 Accident in Texas City Refinery 2005 march, 23rd

The accident of BP refinery in Texas on March 23rd, 2005 should remain in all memories in order to learn lessons of what happened (15 fatalities, 170 severely injured, 700 million dollars to the victims, 2.3 million for OSHA[4] safety and hygiene violations, plus the ones corresponding to environmental violations).

Baker's report (January, 2007) [5] starts like that: « Other companies and their stakeholders can benefit from our work. We urge these companies to regularly and thoroughly evaluate their safety culture ». Here can be highlighted a very classical question: could we expect such an accident by meaning of specific indicators? Baker's report indicates: « The literature also suggests and the panel believes that the presence of an effective personal safety management system does not ensure the presence of an effective process safety management system. As discussed elsewhere in this report, BP's personal injury rates were not predictive of process safety performance at BP's five US refineries ». There are other comments about this topic: « BP has emphasized personal safety in recent years and has achieved significant improvement in personal safety performance, but BP did not emphasize process safety. BP mistakenly interpreted improving personal injury rates as an indication of acceptable process safety performance at its US refineries. BP's reliance on this data, combined with inadequate process safety understanding, created a false sense of confidence that BP was properly addressing safety risks. The panel further found that process safety leadership appeared to have suffered as a result of high turnover of refinery plant managers ».

To reduce occupational accidents, BP had launched programmes to improve behavior and risk awareness, which were successful to decrease the conventional frequency rate of lost time accident by 70 %. By only referring to this indicator, one could feel honestly to improve situation [6]. But at the same time: shift operators were working more than 30 successive 12 hours shifts, 8 plant managers were successively hired over a period of 6 years on site composed with 1 800 BP staff and 2 000 outside workers. In addition to that, 300 violations were identified on equipments by several surveys following the accidents and we can remind that the year before the explosion, there were 2 fatalities in the refinery (in 2004).

The question of global coherence is raised.

Baker's report (others can be found, e.g. Mogford's report, December 9th, 2005) puts in evidence some important causes: lack of maintenance, lack of process safety management and associated expertise. These causes are not reported [7] in usual scorecards [8] compared to CFR.

These are prevention strategies after the accident: As a consequence and following the conclusions of various reports, BP launched several programmes on leadership and on process safety management (PSM) and planned to invest 1 billion dollars over a 5 years period in the refinery. The Group decided to internalize some technical activities that had been outsourced during the past and to reinforce internal expertise.

3 How to implement efficient prevention strategies

Consequently, it is possible to improve CFR year by year by working on programme based on behavior and awareness, while at the same moment reducing annual maintenance or training budget or specific expertise that are mandatory for future performance, even for sustained business. This point has especially to be taken into account when considering manager turnover. A too big turnover can introduce strong bias, e.g. to get quick wins only compared to long term actions which are fundamental. The system of annual objectives must take into account those dimensions and must ensure a full coherence between short term and long term objectives. As for example, ergonomic: to avoid hazardous situations that will generate problems in the future (when managers will have turned over). Organizations must ensure short term and long term coherence: both are important and interact.

[3] Conventional Frequency Rate
[4] Occupational Safety and Health Administration – United States

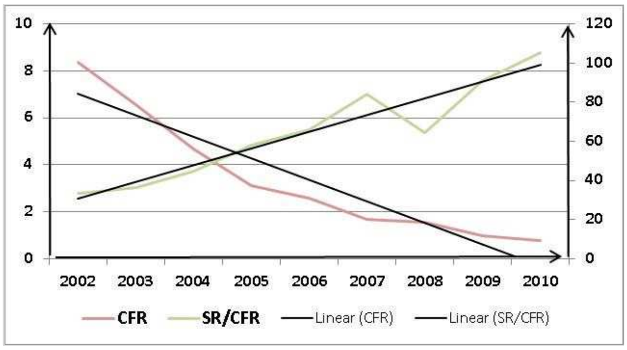

Figure 3: CFR versus DPLTA

We can give another example for a big company in the business of civil engineering and raw materials. We can determine that for a period of 10 years, the duration of days lost per lost time accident (DPLTA)[5] is increasing almost continuously from around 30 days to 100 days while CFR is decreasing continuously (Figure 3).

It appears that there are fewer accidents but much more severe ones. Based only on CFR, you could consider that prevention is improving, but by taking into account DPLTA, the prevention is worse.

Even more if we consider the sustainability reports of this company, there is an interesting benchmark with other companies working in the same business:

While this company is improving its score on CFR, it is worsening for fatalities (Figure 4). In the same time, both CFR and SR[6] are decreasing, meaning an improvement, whereas DPLTA and fatalities are increasing, reflecting a worsening (Figure 5).

Therefore, if each indicator is considered separately, the view of the situation is mistaken, since some indicators could consider the situation as an improvement and others ones as a worsening. Consequently, all indicators should be compared in order to put in evidence the field reality.

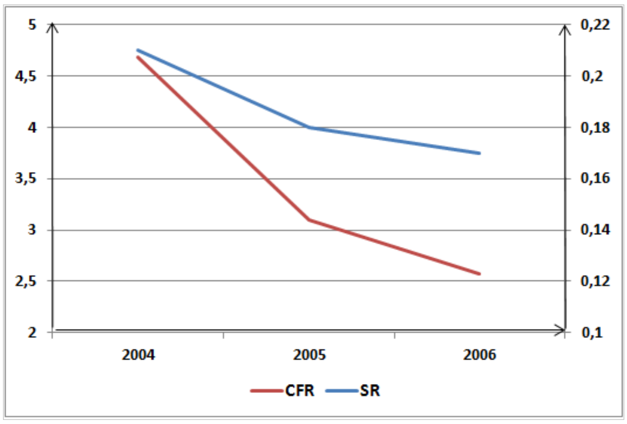

Figure 4: CFR versus SR

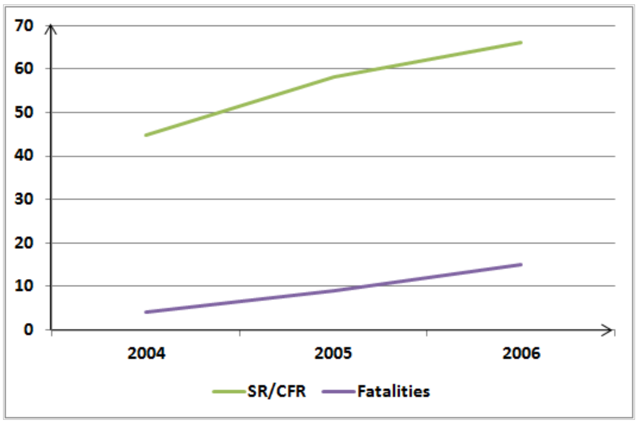

Figure 5: CFR versus SR

There are the ranking results for the frequency rate and the severity rate of this company compared to others companies working in the same sector for 2006, 2007, 2008 and 2010:

- Benchmark/ Sustainability Report 2006

Frequency rate: 9 companies have published their frequency rate of occupational lost-time accident. The company is ranked 4th. For this indicator, its performance has increased in 2006.

Severity rate: 6 companies have published their gravity rate in 2005. The company is ranked 4th and its performance has decreased the next year.

- Benchmark/ Sustainability Report 2007

Frequency rate: 9 companies have published their frequency rate of occupational lost-time accident in 2006. The company is ranked second whereas it was 4th the previous year.

Severity rate: 6 companies have published their results in 2006. The company comes last in this group.

Two companies have zero accident. The company is continuing to aim this objective. In 2007, its performance is increased in this sector.

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[5] $DPLTA = \frac{SR}{CFR.10^3}$
days lost per lost time accident times 1000 e.g. the severity of each accident.
[6] Severity Rate

- Benchmark/ Sustainability Report 2008

Frequency rate: 9 companies have published their results for this indicator, and the company is ranked second.

Severity rate: 7 companies have published their results in 2007. The company is ranked 6th.

For this year, two companies also showed a gravity rate of zero. The company is continuing to tend towards this aim and some progress has been made in 2008.

- Benchmark/ Sustainability Report 2010

9 others members of CSI also made a reporting of their performance on some or all of indicators. The comparison is based on data from 2009.

For the frequency rate of occupational lost-time accident, the company is ranked 2nd of 7.

For the severity rate, the company is ranked 7th of 9 companies.

To conclude, the company has improved its frequency rate, which is often due to a zero accident policy, but in the same time, the number of fatal accidents has increased. The control of the most frequent events, when it is needed, is not sufficient for decreasing the effects of accidents.

Global control of risks must be based on prioritizing as regulation is requiring too. When companies want to improve EHS[7] performance [9], they have to define the right models and indicators because the top managers will then focus on them [10]. Let us remind the comments from Herbert Simon's economic Nobel Prize: « the most important resource is not information but the awareness of actors ». When top managers are committed to safety, we must have relevant indicators to assess the efficiency of policies. What is also important is to ask oneself as far as possible and as often as possible the right questions. Then to understand and act in the right direction, as Deming used to say, « Best efforts are not enough; you have to know where to go ».

4 Conclusion

The various sociotechnical activities need specific control system adapted to the stakes and complexity of their environment in order to reach their goals. In the field of prevention of risks for workers, ethical and human issues are paramount. Based on statistics from International Labor Organization and Worldwide Health Organization [1], we can give the following data. There are 2 000 000 fatalities at work each year worldwide divided in 1 700 000 fatalities due to occupational diseases and 300 000 due to occupational accidents (plus 268 million lost time accidents more than 3 days out of work).

Politics have to develop strong vision and concrete policies of prevention to solve this very important problem for the whole world.

When reading various Sustainable Corporate Reports [11], we can notice that some companies take into account the CFR of outside contractors but this is not generalized. To compare companies using widely subcontractors in a more relevant way this activity would have to be included. Moreover, in order to use statistics properly, we have to be rigorous and do not use data out of their context. Indeed to determine if the CFR is "good or not", it can be useful to know the average of companies from the same sector of activity. How can be relevant to compare companies from so different sectors as construction or pharmaceuticals?

Then CFR does not demonstrate necessarily the existence of direct links with efforts invested in safety and health programmes and improvements achieved.

So CFR is one of the most used indicators of the Safety Management System to measure company performance but this indicator has got intrinsic limits. It must then be used with other indicators that demonstrate all together the level of risk control. It should be appropriate to put in place other indicators such as the participation rate or the measure of efficiency with time if we want to demonstrate what makes the system work or result indicators such as the measure of the number of accidents avoided for instance to show the impact of actions.

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