

The Effectiveness of 48 Safety Interventions According to Safety Professionals

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In The Netherlands, approximately 2.300 workers have a serious reportable accident at work every year, of which around 60 are fatal (Bellamy et al., 2014). Safety professionals employ many methods to improve safety for workers within their companies. Interventions might, for example, be aimed at improving companies' overall 'safety culture', at the introduction of a safety management system (e.g. Robson et al., 2007), or at improving the compliance of workers to specific safety rules (e.g. Peuscher and Groeneweg 2012; Bryden et al., 2016). The effectiveness of many of those interventions remains however largely unclear (Dyrborg et al., 2015). The Dutch National Institute for Public Health and the Environment (RIVM) has started a project with the ultimate goal of developing a database filled with 'effective safety interventions'. The interventions can be submitted by their developers using a fixed protocol. To support this project, a survey was developed, which was sent to all members of the Dutch Society for Safety Science (NVVK). In the survey, a list of 48 predefined descriptions of common interventions was used. Respondents indicated whether they made use of these common interventions and the extent to which they considered these effective. The survey thus provided an extensive overview of the use and perceived effectiveness of 48 specific safety interventions. In the near future, these insights can support the development and testing of more effective safety interventions.

1. Introduction

In The Netherlands, approximately 2.300 workers have a serious reportable accident at work every year, of which around 60 are fatal (Bellamy et al., 2014). The (in)direct consequences of fatal and non-fatal work-related accidents for victims, organisations and society have been documented extensively. Examples are loss of life, lost working years and lost productivity (e.g. Pedersen, Nielsen & Kines, 2012).

Safety professionals employ different interventions to improve safety for workers within their companies. Interventions have been defined in different ways. Robson et al. (2001), for example, define an intervention as "an attempt to change how things are done in order to improve safety. Within the workplace it could be any new program, practice or initiative intended to improve safety" (p. 1). Masi & Cagno (2015) define an occupational health and safety intervention as "an attempt to improve safety and health conditions in workplaces by means of targeted activities and initiatives." (p. 227). Another definition comes from Oyewole et al. (2010): "A safety intervention could be described as an attempt to alter or change how things are done in order to improve safety" (p. 585).

These definitions are different but clearly related, key elements appear to be that safety interventions are:

- Goal oriented (e.g. towards improving safety).
- Systematic and intentional (e.g. programs, targeted activities).
- An approach which is oriented towards a change in the status quo, i.e. how work is usually done.

With respect to this project, we have considered a requirement for changing the status quo to be overly constraining. If an approach is continuous and embedded within the organisation it could, in our definition, still be defined as a safety intervention provided it is goal oriented and systematic. We have come to define a safety intervention as: “an intentional effort to systematically improve ‘safety’ within a work organisation through a series of actions, measures and/or steps which are seen as related to each other”.

Many interventions and intervention strategies aimed at reducing occupational injuries and deaths have been implemented and tested (Pedersen, Nielsen & Kines, 2012). For example, interventions that improve the safety climate in an organization (e.g. Bronkhorst, Tummers and Steijn, 2018), improve the compliance of workers to specific safety rules (e.g. Peuscher and Groeneweg, 2012; Bryden et al., 2016) or introduce a safety management system (e.g. Robson et al., 2007), or an elaborate intervention like a safety and health program (Oyewole et al., 2010). Other examples are more specific and are directed at for example specific groups (e.g. migrant workers (Caffaro et al., 2017)) or specific accident scenarios (e.g. the prevention of falls (Goh & Goh, 2016)). Evaluating whether these interventions are indeed effective in improving safety is important (Pedersen, Nielsen & Kines, 2012). However, evaluations of interventions are difficult to carry out. In the normal daily practice of a company, interventions to improve safety “do not come in single, neat packages allowing clear before and after assessment of their effect on performance” (Hale et al., 2010, p. 1027-1028). In addition, effects may be relatively small, which requires a larger sample size and sample period than is commonly used (Hauer, 1997).

It is noted that many interventions have multiple desired final outcomes. They may include different output measures directly related to safety such as number of accidents or the time absent from work (Hale et al., 2010). In addition, safety interventions may be related to other outcome measures such as workplace productivity (Robson et al., 2007) and/or intermediate variables such as reporting unsafe or dangerous situations (Hale et al., 2010), employee safety knowledge or safety climate (Robson et al., 2007).

The outcomes of an intervention are not only determined by the intentional characteristics of the approach which is undertaken but are also strongly influenced by other (contextual) factors (Nielsen & Miraglia, 2017). Moreover, it is almost never possible, or ethical, to randomly select companies or teams as case or control group (Pedersen, Nielsen & Kines, 2012). Process evaluation studies have shown that many different factors than just the intervention can influence differences between the control and case groups (Nielsen et al., 2006). Many studies therefore emphasize that also contextual factors are crucial in understanding the effectiveness of an intervention (e.g. Abildgaard, Saksvik & Nielsen, 2016; Masi & Cagno, 2015; Nielsen et al., 2006; Pedersen, Nielsen & Kines, 2012, Robson et al., 2007).

Overall it can be said that studying safety interventions is challenging: they are not defined unambiguously, are difficult to isolate and study within companies, are often multi-faceted and may work differently depending on (organizational) contextual factors. Despite these difficulties, many (safety) professionals who work at companies still develop, adapt and implement many different safety interventions. In the present study we attempt to gain more insight into the experiences of these professionals. What interventions do they use, why do they use them and how do they take account of the context in which they implement their interventions?

2. Method

To study which interventions Dutch safety professionals implement in their companies and the extent to which they think these interventions are effective, we carried out a survey. The survey was developed by the Dutch National Institute for Public Health and the Environment (RIVM), TNO Leiden and Delft University of Technology.

The survey had four main parts that are relevant for the current paper:

1. Inventory of interventions (What does your company do regarding safety interventions?)
2. Effect of the intervention (What has most improved safety in your company?)
3. Aspects of the intervention strategy (e.g. Why do you choose one intervention over another?)
4. Examples of ‘hits’ & ‘misses’ (Describe an intervention that you recommend to others and one which you would not recommend to others?).

2.1 Participants

We administered the survey in cooperation with the NVVK, the professional body for safety professionals in the Netherlands. The NVVK regularly sends email messages to all its members, which typically work as safety professionals in, for example, safety departments, HR departments or as independent consultants. We invited all NVVK-members to participate in the survey, and indeed 297 members did participate (approximately, a 12 percent response rate). These professionals work in many different sectors, with the majority working in industry (35%), building and construction (9%), public service organisations (8%) and other sectors (12%). SEVESO and non-SEVESO companies were both part of the sample. A substantial proportion of the

respondents (22%) work in companies in which accidents are quite rare. The so called 'Lost Time Injury Frequency' (LTIF) statistic for these companies was reported to be below 1 accident leading to days away from work per 1 million hours worked.

2.2 Survey development

We expected that the companies in which the safety professionals were working would typically be using several different interventions and approaches. Therefore, it was decided to develop a survey with a structured response format, which could help respondents to take a broad and comprehensive view on the interventions within their companies. Some open-ended questions were included as well in order to collect narrative descriptions where deemed appropriate. As a first step it was necessary to develop a limited list of common types of interventions, developed by brainstorming with experts, and with feedback on a pre-test. Furthermore, an open-field response was included which allowed respondents to share information in case a particular type of intervention would have been missing from the compiled list.

After this process, the final list consisted of 48 different types of interventions. For each intervention type the respondents indicated whether they used that particular approach within their company (yes/no). In a later part of the survey, we again presented the intervention types respondents earlier had indicated they use in their company. From this (shorter) list they were asked to select the three interventions which they thought improved safety in their company most. Table 1 shows the list of 48 intervention types which were included in the survey as well as quantitative summaries of the main results.

In addition to the list of intervention types, we included some items that addressed aspects of the intervention strategy within the company. Specifically, the survey asked about reasons for implementing safety interventions; reasons for choosing a particular type of safety intervention; the development of a coherent plan for different interventions and the main goals of the safety interventions. Another two items asked respondents to describe in free text a specific example of an intervention that they would recommend to others and one which they would not recommend to others. Finally, participants were asked to provide some background information concerning the organization they work for (such as, sector, size, and LTI) and some concluding questions that are not reported on in this paper.

Table 1: Intervention types, the proportion of respondents that use a particular intervention and the proportion of those users, which considered it one of their 'three most effective interventions'.

| Theme | Some examples of intervention types within the themes | % Used | % Top 3 Most Effective |
|--------------------|--|--------|------------------------|
| Cooperation | Leadership training focused on safety roles | 75% | 35% |
| | Organising a safety day | 52% | 12% |
| | Surveys on employee safety perceptions and experiences | 53% | 6% |
| Systems | Sanctioning individual employees for non-compliance | 55% | 4% |
| | A final safety check just before starting work (LMRA) | 72% | 12% |
| | Systematic scheduled discussion of safety issues within the company | 80% | 15% |
| Knowledge | Individual certified safety training for employees | 85% | 7% |
| | Campaign focused on improving employee safety behaviour (e.g. posters) | 62% | 8% |
| | Gate instruction for suppliers and contractors specifying safety rules | 72% | 2% |
| Technology | Procedure or method for reducing hazards at the source (inherent safety) | 81% | 9% |
| | Management of change procedures | 57% | 12% |
| | Safety symbols on dangerous objects, machines, rooms or equipment | 93% | 1% |
| Evaluation | Reporting, cataloguing and investigating (near) accidents | 97% | 24% |
| | External audit of SMS | 73% | 3% |
| Analyzing | General risk inventory and assessment | 98% | 10% |
| | Additional risk assessments (e.g. QRA, HAZOP, FMEA, Bowtie) | 64% | 6% |

2.3 Analysis

We collected our data using web-based survey software. We computed descriptive statistics such as the proportion of respondents which indicated that they use a particular intervention as well as the proportion of respondents which used a particular intervention and considered it most effective. Finally, the open text fields were analyzed qualitatively.

3. Results

In Table 1 we show examples of the intervention types that were included in the survey. In the same table we show the proportion of all 297 respondents which made use of these particular intervention types (column A) and the proportion of those users which considered it to be one of their ‘three most effective interventions’. Due to space constraints not all 48 interventions are shown in table 1, the full list is available on request. On average, the respondents reported using 32 interventions. Figure 1 shows the five most used interventions and the five least used interventions and approaches. Interventions which are relatively common in the group are, for example, a general risk inventory and assessment (every company in The Netherlands is required by law to have one) and the reporting, classifying and investigating of (near) accidents. Uncommon interventions were campaigns focused on preventing worker stress and the measure of including safety performance in managerial reward structures.

In addition, 65 respondents gave a ‘free text’ response to a question whether any interventions had been missed in the list. Some of these responses contained unrelated information or additional clarification. Further responses generally gave a more specific description of an intervention, which could also be classified under an intervention type which was already in the list.

We also asked respondents about the main reasons for implementing specific interventions. Respondents could chose up to three reasons out of seven. Legal requirements were an important consideration as well as its use by other organisations as well as stakeholder preferences. The importance of a legal requirement is also apparent in Figure 1 and Table 1 as it shows that the intervention most used is ‘a general risk inventory and assessment’ for which a legal requirement exists.

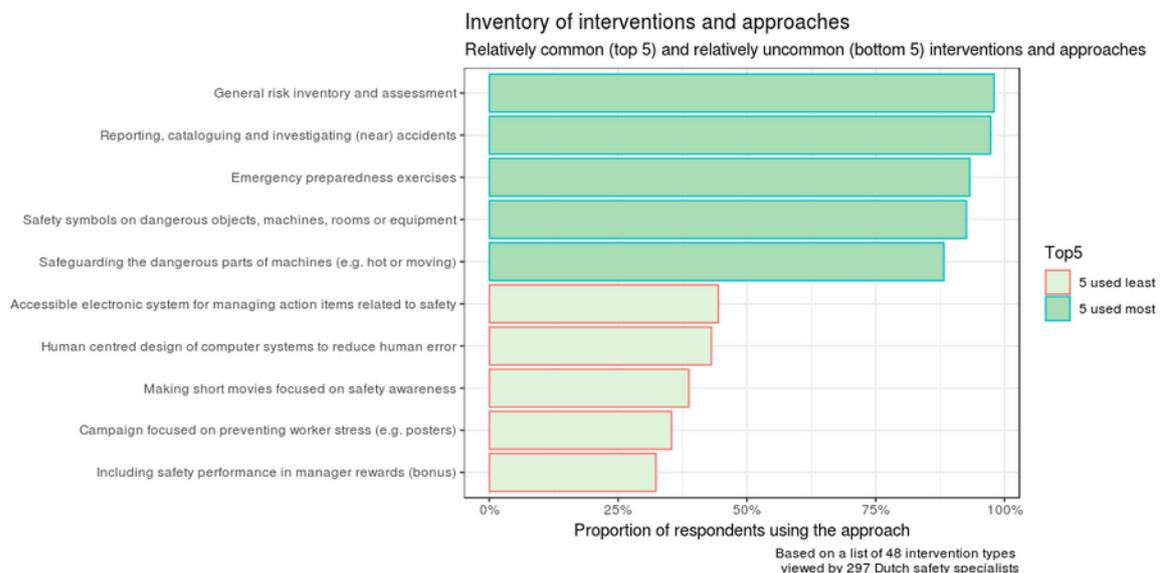


Figure 1: Relatively common (top 5) and uncommon (bottom 5) interventions and approaches.

When asked about their most effective interventions, the respondents show a clear preference. Figure 2 shows a list of five interventions included most often in the ‘top 3’ of the participating professionals.

As we can gather from Figure 2 and Table 1, respondents have a clear preference for particular interventions, safety training for employees and leadership in particular. Many other interventions from the original list were never or almost never considered to be particularly effective by the respondents; e.g. information on hazardous machines, human-centered design of computer systems, campaigns focused on worker stress.

The free text questions, with which respondents described which interventions they would and would not recommend to others, were filled in by approximately 150 respondents providing over 300 detailed

descriptions. Remarkably, one could say that one man's hit is another man's miss. Intervention types mentioned as a main recommendation by one respondent could have a strong non-recommendation by another respondent. One respondent, for example, wrote: "a well-executed LMRA. We use coaching to maintain a good quality LMRA and to keep improving it", whilst another respondent claimed: "LMRA that uses tick-off boxes. With time employees know the patterns of the tick-off boxes without noticing the accompanying text anymore". It appears that the approach used for implementation as well as the conditions which are present in the two companies exert a crucial influence in these two examples. A further analysis of recurrent themes in the free text responses showed that descriptions of successful interventions often referred to the role of direct managerial involvement and the fostering of employee safety awareness. With respect to interventions that were not recommended, a 'culture of fear' or focusing overly on sanctioning were regularly mentioned. In addition, respondents did not recommend interventions conducted in a 'minimal' or 'simplistic' way and those which were overly reliant on administrative procedures.

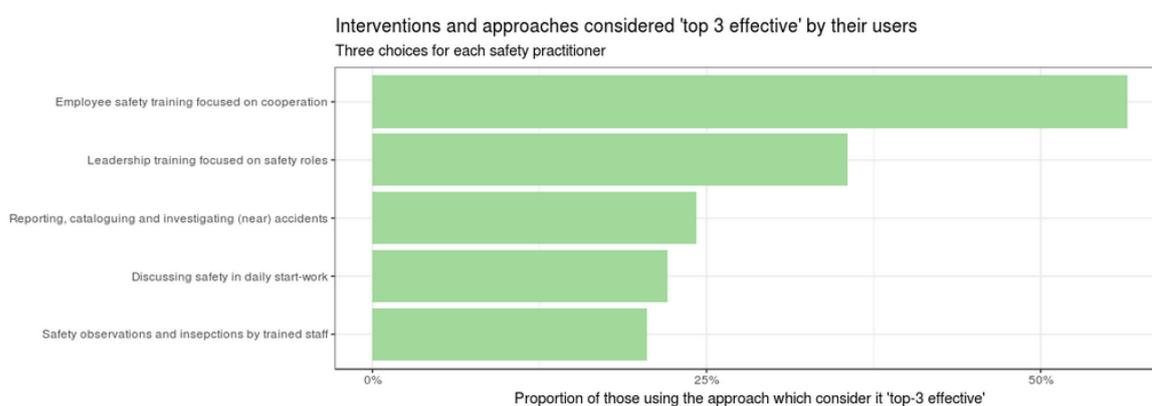


Figure 2: Five interventions which are most often thought of as 'top 3 effective' by their users.

4. Conclusion and discussion

From previous research it has become clear that successful intervention programs consist of twice as many (separate) interventions as unsuccessful ones (Hale et al., 2010) and that a multifaceted intervention program seems to be the optimal choice (Bronkhorst et al., 2018). The Dutch safety professionals that participated apply this strategy as well. They indicate to use an average of 32 interventions in their companies when they can choose from a list of 48. This study provides a broad overview of the wide variety of types of interventions which are commonly employed by this group. All interventions offered were picked by the respondents and the additional free text field did not indicate that we missed a major type of intervention. The safety professionals report that they select particular interventions often based on legal requirements and success stories from other companies. Evidence-based, status and costs are less important considerations. This reinforces the role of legislators in the promotion of certain safety interventions. Secondly, it shows that sharing best practices from other companies can help spread effective approaches.

The safety professionals in our survey have a clear preference for interventions which they think improve safety most, like employee training, management training and accident investigation. Many commonly used interventions are not considered particularly effective for improving safety or, at least, respondents did not include them in their 'top three'. Examples include instructions at the (front) gate, auditing and placing safety symbols (for example on a dangerous machine). It should be stressed that this study reports perceived effectiveness and did not determine the actual effectiveness of the different types of interventions. Some interventions may not be perceived as effective because they have existed for a long time (e.g. applying safety symbols to machinery). In addition, while one safety professional would recommend an intervention type to others, the same intervention type may be considered a 'miss' by another professional.

It is worrisome that scientific evidence only seems to play a minor part in the respondents' choice for a particular safety intervention. It raises the question whether scientific knowledge is sufficiently available, accessible and usable in practice. Future research on the effectiveness of interventions is needed. This research should study not only the overt characteristics of a particular approach but should also investigate the conditions under which the approach can be implemented successfully in practice. Factors such as managerial commitment and avoiding a 'blame culture' could play an important part here.

A more objective understanding of the effectiveness of interventions could benefit safety practitioners, although finding new ways of disseminating this information will be a challenge. A project is currently

underway aimed at gathering descriptions of effective safety interventions within a central database. The project is run by The Dutch National Institute for Public Health and the Environment (RIVM) in cooperation with potential users. The ultimate goal of this project is to connect scientific knowledge on effective interventions with the practical experience of safety practitioners within an accessible structure. Moving from perceived effectiveness to evidence-based judgements can ensure a sound basis for furthering occupational safety.

References

- Abildgaard J.S., Saksvik P.Ø., Nielsen K. 2016. How to Measure the Intervention Process? An Assessment of Qualitative and Quantitative Approaches to Data Collection in the Process Evaluation of Organizational Interventions. *Frontiers in Psychology*, 22(7),1380
- Bellamy, L.J., Manuel, H.J., Oh, J.I.H., 2014, Investigated Serious Occupational Accidents in The Netherlands, 1998-2009, *International Journal of Occupational Safety and Ergonomics (JOSE)*, 20(1), 19-32.
- Bronkhorst, B., Tummers, L., Steijn, B., 2018, Improving safety climate and behavior through a multifaceted intervention: Results from a field experiment, *Safety Science*, 103, 293-304.
- Bryden, R., Gradinger, S., Dick, N., Paul, T., 2016, Re-Energising the Life-Saving Rules. Paper presented at the Society of Petroleum Engineers, SPE International Conference and Exhibition on Health, Safety, Security, Environment, and Social Responsibility, 11-13 April, Stavanger, Norway.
- Caffaro, F., Bagagiolo, G., Cremasco, M.M., Cavallo, E., 2017, Participatory ergonomic design of a safety training tool for migrant workers in agriculture, *Chemical Engineering Transactions*, 58, 23-30.
- Dyreborg, J., Lipscomb, H.J., Olsen, O., Törner, M., Nielsen, K., Lund, J., Kines, P., Guldenmund F., Bengtsen, E., Gensby, U., Rasmussen, K., Zohar, D., 2015, Safety Interventions for the Prevention of Accidents at Work, PROTOCOL. ID NO. SW2010-05.
- Goh, Y.M., Goh, W.M., 2016, Investigating the effectiveness of fall prevention plan and success factors for program-based safety interventions, 87, 186-194.
- Hale, A.R., Guldenmund, F.W., van Loenhout, P.L.C.H., Oh, J.I.H., 2010, Evaluating safety managers and culture interventions to improve safety: Effective intervention strategies, *Safety Science*, 48, 1026-1035.
- Hauer, E. 1997. *Observational before and after studies in road safety*. Pergamon, Elsevier Science LTD, UK
- Masi, D., Cagno, E., 2015, Barriers to OHS interventions in small and medium-sized enterprises, *Safety Science*, 71, 226-241.
- Nielsen, K., Fredslund, H., Christensen, K.B., Albertsen, K., 2006, Success or failure? Interpreting and understanding the impact of interventions in four similar worksites, *Work & Stress*, 20(3), 272-287.
- Nielsen, K., Miraglia, M., 2017, What works for whom in which circumstances? On the need to move beyond the 'what works?' question in organizational intervention research, *Human Relations*, 70(1), 40-62.
- Oyewole, S.A., Haight, J.M., Freivalds, A., Cannon, D.J., Rothrock, L., 2010, Statistical evaluation and analysis of safety intervention in the determination of an effective resource allocation strategy, *Journal of Loss Prevention in the Process Industries*, 23, 585-593.
- Pederson, L.M., Nielsen, K.J., Kines, P., 2012, Realistic evaluation as a new way to design and evaluate occupational safety interventions, *Safety Science*, 50, 48-54.
- Peuscher, W., Groeneweg, J. 2012. A big oil company's approach to significantly reduce fatal incidents. International conference on health safety and the environment in oil and gas exploration and production. Perth 11-13 september
- Robson, L.S., Clarke, J.A., Cullen, K., Bielecky, A., Severin, C., Bigelow, P.L., Irvin, E., Culyer, A., Mahood, Q., 2007. The effectiveness of occupational health and safety management system interventions: A systematic review, *Safety Science*, 45, 329-353.
- Robson, L.S., Shannon, H.S., Goldenhar, L.M., Hale, A.R. (2001). *Guide to evaluating the effectiveness of strategies for preventing work injuries: How to show whether a safety intervention really works*. National Institute for Occupational Safety and Health (NIOSH).