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Original Article

An Intervention Study on the Implementation of Control Banding in Controlling Exposure to Hazardous Chemicals in Small and Medium-sized Enterprises

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ABSTRACT

Background: Management and workers in small and medium-sized enterprises (SMEs) often find it hard to comprehend the requirements related to controlling risks due to exposure to substances. An intervention study was set up in order to support 45 SMEs in improving the management of the risks of occupational exposure to chemicals, and in using the control banding tool and exposure model Stoffenmanager in this process.

Methods: A 2-year intervention study was carried out, in which a mix of individual and collective training and support was offered, and baseline and effect measurements were carried out by means of structured interviews, in order to measure progress made. A seven-phase implementation evolutionary ladder was used for this purpose. Success and failure factors were identified by means of company visits and structured interviews.

Results: Most companies clearly moved upwards on the implementation evolutionary ladder; 76% of the companies by at least one phase, and 62% by at least two phases. Success and failure factors were described.

Conclusion: Active training and coaching helped the participating companies to improve their chemical risk management, and to avoid making mistakes when using and applying Stoffenmanager. The use of validated tools embedded in a community platform appears to support companies to organize and structure their chemical risk management in a business-wise manner, but much depends upon motivated occupational health and safety (OHS) professionals, management support, and willingness to invest time and means.

1. Introduction

In many small and medium-sized enterprises (SMEs), awareness of the long-term health impacts of exposure to hazardous substances is low. This is despite recent estimates which show that in the European Union alone, 74,000 workers die every year as a result of occupational diseases caused by hazardous substances, and roughly ~10 times more workers get an occupational disease [1]. Worldwide, ~632,500 deaths and > 7 million lost healthy life years can be attributed to occupational exposure to hazardous substances each year [2]. For management and workers in SMEs, however, given their limited resources, it is not an easy task to comprehend the legal requirements related to controlling risks due to exposure to substances [3]. Besides, it is not an easy task to uncover the company-specific burden of disease related to this exposure, and to show the benefits that may be expected from interventions to reduce exposure.

In various countries, tools have been developed that support companies in preparing risk assessments and in selecting the proper risk management measures. One type of such tool, which has gained substantial interest and adoption worldwide, is control banding. Control banding is a qualitative risk assessment in which

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categories ("bands") of hazards are combined with categories (bands) of the exposure potential, in order to arrive at risk estimates and—subsequently— recommended levels of controls [4,5]. Control banding approaches were first developed by the pharmaceutical industry in the late 1980s, and have found considerable application in risk management of substances [4,6]. One more recent application of control banding is to enable companies to prepare preliminary risk assessments for nanomaterials in the absence of firm toxicological and exposure data [5–7]. Control banding may be applied when uncertainty on hazards and exposure is high, but where nevertheless, more or less reliable estimations can be made by grouping the substances used in hazard categories and the activities carried out in exposure categories [6].

Stoffenmanager at www.stoffenmanager.nl being one of such tools [8,9] is a web-based, free to use instrument that offers both control banding, i.e., a qualitative risk assessment model for both inhalation and dermal risks—and a validated quantitative model to estimate exposure by inhalation. The first version of Stoffenmanager was launched in 2002. The Dutch Labor Inspectorate has approved the quantitative model as a reliable tool to assess exposure. Moreover, the tool has been adopted in the relevant guidance documents on risk assessment within the framework of the Registration, Evaluation, and Authorization of Chemicals (REACH) legislation, from the European Chemicals Agency (ECHA). Currently, Stoffenmanager has > 25,000 registered users, which have access to an online community which provides information, mutual support, and access to occupational health and safety specialists.

Significant efforts have been put in designing Stoffenmanager with a user-friendly interface [8]. As a result of this, and as a result of its active promotion by various stakeholders, including the Dutch Labor Inspectorate, the level of implementation in companies has risen steadily over recent years. However, it has appeared that just 'offering' a control banding tool, without providing active support, does not automatically result in its use by SMEs, and even less in a 'proper' use. In the context of this article, 'proper' use means that the parameters entered in the tool by the user reflect the true exposure scenario that is being assessed, taking into account the applicability domain of the tool.

A review among 755 registered users of Stoffenmanager in The Netherlands showed that only 26% of them had actually entered any data into the tool [10]. The operational analysis of control banding tools, i.e., an analysis of the intended user's understanding and implementation, has been sparsely represented in the published literature. However, there is an urgent need for this in order to find out if, and to assure that, the intended users are able to prepare complete and reliable risk assessments, and to take the appropriate control measures [4,6]. The few published studies in this field do not seem to justify much optimism in this respect. An extensive usability evaluation of the British, internet based COSHH-Essentials tool (www.coshh-essentials.org.uk) showed that the intended users got confused by the tool's focus on tasks rather than substances, as well as by the tool's structure and interface, while—according to the authors—the tool did not cater for the different user types, with different existing levels of knowledge [11]. However, one might wonder whether tools should either cater for different levels of knowledge, or be easy to use for a wide range of potential users.

A more recent evaluation of the reliability of the Advanced REACH Tool (https://www.advancedreachtool.com/), a more sophisticated exposure assessment model [9], showed similar results. Even a selected group of trained occupational hygienists showed that, although at group level the assessor's results showed good agreement with the 'gold standard' defined by the authors, substantial variability was observed between individual assessors' estimates for an individual scenario [12]. In a number of cases, the assessors did not appear to be able to implement the information that was explicitly provided with the scenarios to be assessed. Therefore, the authors recommended extensive training prior to using quantitative exposure models such as these [12]. Finally, a recent between-user reliability exercise with five currently used quantitative exposure assessment models, and 146 participants, learned that significant between-user variation occurred in selecting various parameters that have to be entered into these tools [13]. The variability was not likely due to differences in the users' backgrounds and levels of knowledge in using exposure assessment tools, as there did not appear to be any systematic difference on these aspects. The authors concluded that more needed to be done to ensure consistency, such as providing improved guidance and explanation, and providing training prior to using exposure assessment tools [13]. Moreover, it was concluded that users must understand the limitations of the tools in terms of applicability and output, which is why reading the guidance and supporting material was regarded essential [13].

1.1. This research

The developers of Stoffenmanager in the Netherlands—TNO, Arbo Unie, and Ernst & Young/BECO—have recognized the need for a more active approach and support to SMEs, in order to foster an active as well as a proper use of this tool. Therefore, a 2-year intervention project was started, in which active support was provided to a group of 45 participating companies—most of them SMEs. The project aimed at improving the implementation of Stoffenmanager as well as chemical risk management in a wider sense. In order to find hints to enable the development of tailored support to companies willing to optimize chemicals' management, the central research question addressed within the framework of this project was: "which characteristics of the tool Stoffenmanager itself, of the intended user and of the intended user's organization determine the success or failure of its active and successful implementation and proper use?".

2. Materials and methods

Most participants used the generic, free to use 'basic' version 5.0 of the online Stoffenmanager tool during the project. A small proportion of the participants, i.e., five paint manufacturers, used the sector-specific Stoffenmanager for the paint industry. The project was structured as an intervention, encompassing three phases: preintervention (or preimplementation), intervention, and post-intervention (Fig. 1).

The baseline and effect surveys were carried out by means of telephone interviews. The actual intervention or implementation phase encompassed a mix of individual and collective training and support, in order to provide access to experts as well as to promote mutual exchange of experiences and mutual learning among the participating companies. No control group was used, as this was regarded practically impossible, given the very dynamic environment the companies operated in, involving many continuously changing technical, personal, and organizational factors as well as autonomous developments.

2.1. Preintervention phase

In the preintervention phase, the participants were recruited, a method for measuring progress in the participating companies was developed, and the baseline survey was carried out. In the course of the project, five to six industrial hygienists working at TNO and Arbo Unie guided the process and carried out the training and

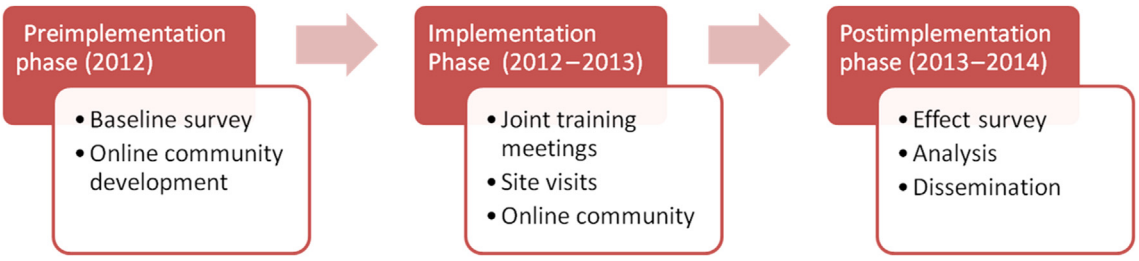

Fig. 1. Intervention process.

support as well as the analysis of success and failure factors in the participating companies.

2.1.1. Recruitment of participants

Companies willing to participate in the project were recruited by means of existing contacts of TNO and Arbo Unie, via the Stoffenmanager e-mail newsletter and by involving two Dutch industry associations in the project team: the Paint and Printing Ink Manufacturers Association (VVVF) and the Rubber and Plastics Manufacturers Association (NRK). A short leaflet was designed, explaining the activities planned and the aims of the project, and presentations were held at regular meetings of the industry associations. The aim of involving 45 organizations was easily met, just as the aim of achieving a mix of small and larger companies from various sectors of industry, having various roles in the supply chain (manufacturer/formulator, end user), as well as nonindustrial organizations (e.g., medical laboratories). Figs. 2–4 present a few characteristics of the participating organizations.

None of the participating organizations employed trained occupational hygienists. Most of the representatives had various responsibilities in the area of quality, safety, health, and environment management, of which chemicals' management was only one aspect (Fig. 4). The representatives took care of transferring the knowledge and skills acquired to a wider group of colleagues within the own organization ('train-the-trainer').

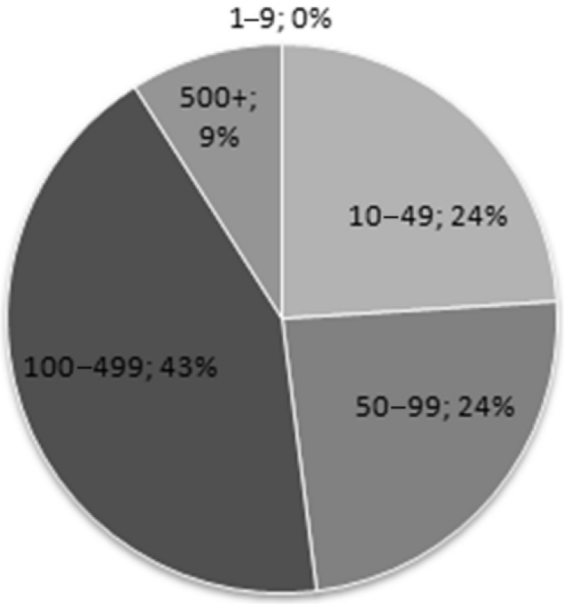

Fig. 3. Size (number of workers) of the participating organizations (baseline measurement).

2.1.2. Measuring progress: the 'implementation evolutionary ladder'

In order to measure progress in the course of implementing the active and proper use of Stoffenmanager by the participants, a seven-phase "implementation evolutionary ladder" was developed,

Fig. 2. Sectors represented by the participating organizations (baseline measurement).

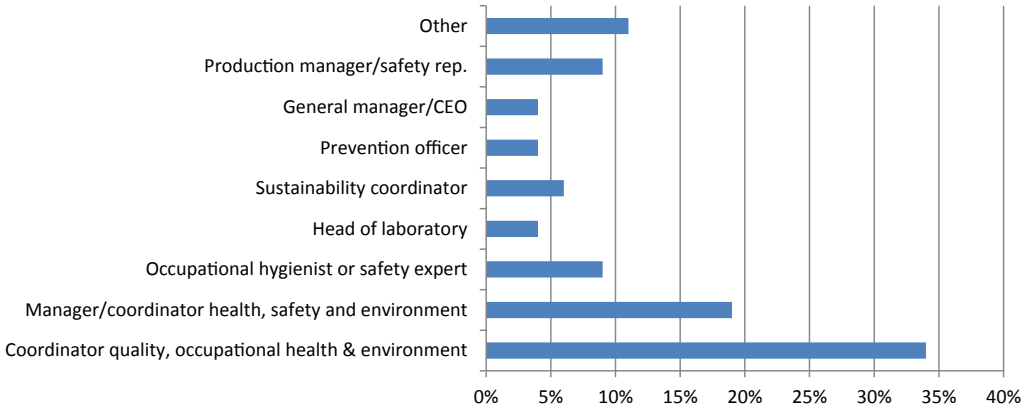

Fig. 4. Job titles of the representatives of the participating organizations (baseline measurement). CEO, chief executive officer; rep, representative.

which is presented in Fig. 5. In order to assign each of the participating organizations to one of the seven phases of the implementation process, a distinct number of core criteria was defined, which were part of the baseline survey. These are presented in Table 1.

2.1.3. Baseline survey

(1) Prior to starting the intervention phase, in each participating organization a baseline survey was carried out. First, a structured interview protocol was developed, consisting of 48 questions, which focused on:general characteristics of the organization and of its representative in the project; (2) general occupational health and safety (OHS)-policies and policies towards chemicals within the organization; and (3) the organization's progress in, and experiences with, using Stoffenmanager. Most of the questions were either binary (yes/no), or had a number of defined answering categories, e.g., number of workers, job title of the representative interviewed, etc. In addition, the interviewees could provide additional comments. The baseline measurement was carried out by means of a telephone interview, using the protocol developed. The answers were as much as possible directly fed into an Excel worksheet for storage and further analysis.

2.2. Implementation phase

The actual intervention—or implementation—consisted of a mixture of collective and individual training, consultancy, and support.

2.2.1. Collective meetings

At the start of the project, after 5 months, and after 10 months, a meeting was organized at which the project team met with representatives from all 45 participating organizations. The meetings were prepared by the project team, with active input from the participating sector organizations. At the first meeting, the results of the baseline survey were shared, and general presentations were given on occupational hazards and risks due to exposure to chemical substances, and on chemical management. In two separate groups, introductions to the qualitative (control banding) model and the quantitative exposure model of Stoffenmanager were offered. The participating organizations were assigned to one of these two groups on the basis of their specific needs, which were reflected by their position on the implementation evolutionary ladder. Subsequently, the participants practiced Stoffenmanager, and experts from TNO and Arbo Unie provided direct support. Additionally, the participants had ample opportunities to exchange experiences and to address specific questions.

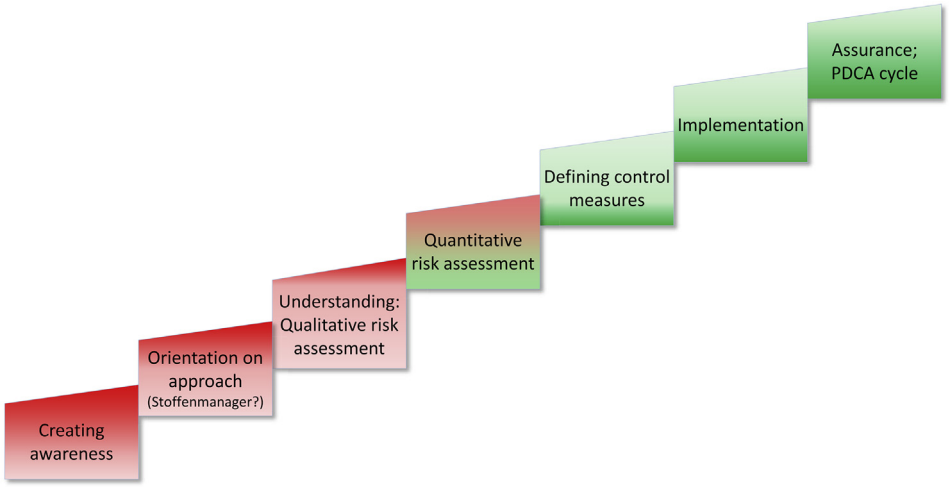

Fig. 5. Stoffenmanager implementation evolutionary ladder with seven phases. PDCA, Plan-Do-Check-Act.

Table 1
Summarized core criteria defining the Implementation-ladder phase of each organization

1	Only a general OSH risk assessment is available; which however, contains a section on chemicals
2	The representative knows the Stoffenmanager model, has a login code and has taken a look at it
3	Data on chemicals have been entered into Stoffenmanager, and the qualitative model has been used
4	The quantitative exposure assessment model in Stoffenmanager has been used
5	Potential control measures have been selected, and their impact on the exposure has been calculated by using Stoffenmanager
6	The feasibility of control measures has been evaluated in detail, and/or their implementation has started
7	The plan-do-check-act cycle has been assured; responsible people and means are available

OSH, Occupational Safety & Health.

The second meeting had a comparable set-up, and included short training modules on specific issues, such as where to find occupational exposure limits for substances. At the third meeting, specific attention was paid to the organizational aspects of chemical management ('safety culture').

Near the end of the project—after 20 months—an additional final meeting was organized, at which the project itself was evaluated with the participants.

2.2.2. Coaches and individual company visits

Each organization was assigned a personal coach, being an OHS specialist of either TNO or Arbo Unie. Each of the coaches had been involved in the development and implementation of the Stoffenmanager tool for many years, and each has contributed to the development of guidance materials and training. In addition, if needed, the coaches discussed specific issues with one another in order to arrive at a common approach. The coach provided individual support by means of e-mail and telephone contact. In addition, the opportunity was offered to have the coach visit the company, in order to deal with specific bottlenecks and questions, to provide on-site support, and to observe the situation and company practices regarding the handling of chemicals. In total 36 companies (80%) made use of this opportunity.

In addition, the company visits were used to interview the participants on a number of aspects related to chemicals' management and the use of Stoffenmanager, in order to identify the success and failure factors determining a successful implementation. In order to facilitate a standardized and structured interview, a checklist was compiled, which focused on five main themes:

(1) preconditions for a successful implementation: support in the organization, availability of time, budget, and means;
(2) using Stoffenmanager: access to information sources needed; user's understanding of the model;
(3) acceptance of the results of the Stoffenmanager assessments (by management/workers); (4) general attitude, motivation, and company policies on substances; and (5) control measures taken and support needed. Finally, each coach visiting an organization identified—by means of the responses given by the participants and expert judgment—the five main success factors and the five main barriers, or failure factors in the organization. The results from the 36 site visits were merged and analyzed partly quantitatively, and partly qualitatively.

2.2.3. Online project community

A dedicated project website was established by Ernst & Young (E&Y), being a protected part within the general Stoffenmanager website. At this website, companies could check their status (phase), and get practical information on the next steps to take in order to improve on the implementation evolutionary ladder. They got access to the project training materials and to other relevant documents and information to support their chemical management. Furthermore, they could exchange experiences by means of a dedicated LinkedIn group, in which the expert coaches took part as well.

2.3. Postimplementation phase

In the postimplementation phase, the effect survey among the participants was carried out, largely using the same telephone interview protocol as was used in the baseline survey. Each company was assigned to one of the seven phases of the implementation ladder again, using the core criteria presented above. A number of additional questions specifically dealt with the participants' judgment of the project activities themselves.

In the postimplementation phase, analysis of the baseline and effect survey took place, and the results of the interviews during the company visits were analyzed. Success and failure factors were described, as well as the 'lessons learned'.

3. Results

In the description of the results, we will first focus on a number of characteristics of the group of participants related to chemical management, at the point of their entry in the project. Subsequently, we will describe their positions on the implementation ladder, at the start and at the end of the project, and on possible causes of the changes observed. Furthermore, we will describe and analyze the success factors and barriers that were identified, including—finally—the impact of the activities offered in the intervention project itself.

3.1. Chemical management and use of Stoffenmanager upon entry in the project

The results of the baseline survey provide some information on the state of affairs related to chemical management and the use of Stoffenmanager in the participants' organizations, at the start of the project. Table 2 provides a number of figures from the baseline survey.

Most of the companies (80%) that had measured exposure, had hired external consultants to do so, while most of the companies (76%) that had used models or tools to estimate exposure had carried that out 'internally'. Finally, only a minority of the participants had already used Stoffenmanager's qualitative or quantitative models to prepare risk assessments. Moreover, roughly twothirds of those who had, found it very complicated—being the reason to join the project for many of them.

Table 2
State of affairs on chemical management – baseline survey ($n = 45$)

89% had prepared a general risk assessment 88% of these risk assessments (78% all over) contained a section on chemicals
100% had some kind of registration of the chemicals that they used
80% had prepared one or more exposure assessments 59% of them (47% all over) by measuring exposure 41% of them (33% all over) by using models or tools
89% already knew Stoffenmanager by name before the start of the project
80% had logged in once, and had taken a look at the model
40% had already used Stoffenmanager's qualitative model (risk prioritization) 60% of them found it 'very complicated'
38% had used Stoffenmanager's quantitative model (exposure calculation) 64% of them found it 'very complicated'

3.2. Position on the implementation ladder

Fig. 6 presents the percentage of companies assigned to each of the seven phases on the implementation ladder, and the shifts that occurred during the project. It is obvious that a considerable shift has occurred. While at the time of the baseline survey 60% of the participants were assigned to either Phase 1 or 2, at the time of the effect measurement ~62% were assigned to Phases 5, 6, or 7. This indicates that a considerable number of participants had made progress in using Stoffenmanager's features such as the qualitative and quantitative risk assessment modules, and that 62% of them had made progress towards selecting and assessing potential control measures, and in starting to implement these.

Fig. 7 provides more detailed information on the shifts that have occurred among the individual participants. Significant variability in the individual participants' progress can be seen. The large majority of the companies made progress of at least one phase up the ladder (76%), and 62% made progress of at least two phases. However, 16% of the participants had made no progress in terms of the core criteria that determined the phase their company was in, and 9% had even moved down. The next section on bottlenecks and barriers to progress that the companies encountered will deal with this issue in more detail.

3.3. Failure factors

The effect survey at the end of the project, by means of telephone interviews among the 45 participants, showed that 78% felt that the project had helped them in getting used to the Stoffenmanager tool and in properly applying the tool. Sixty percent indicated that any kind of bottlenecks still remained. Bottlenecks reported by more than one participant were: (1) in the company the expertise to learn to do more than just putting product data in the Stoffenmanager model—i.e., preparing risk assessments—was lacking; (2) input data were not always available, and (3) some limitations of the Stoffenmanager tool itself, such as easily assessing the exposure to mixtures of substances, and a relative lack of guidance in the tool, e.g., on which "next step" should be taken after making an exposure assessment.

A total of 23% of the participants ($n = 39$) reported that they had not been able to find sufficient time to take part in the project as actively as they would have wished, being a significant cause for the bottlenecks remaining. Further explanations given by companies were the representative in the project leaving the organization without taking care of proper transfer of knowledge, and the economic crisis that forced some companies to shift priorities. These causes were explicitly reported by three of the companies visited ($n = 36$).

Further information on the type of barriers that hindered companies in actively and properly using Stoffenmanager and in securing a responsible chemicals' management has been distilled from the remarks made by companies and the observations made by the coaches during the company visits ($n = 36$). A number of barriers that were observed relatively frequently, will be described below.

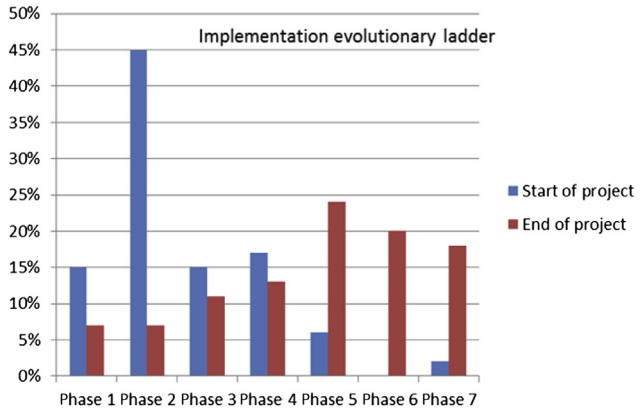

Fig. 6. Percentage of companies assigned to each phase on the Implementation ladder ($n = 45$).

3.3.1. Time investment needed

In all but one of the 36 companies visited (97%), preparing risk assessments for exposure to substances—supported by the use of Stoffenmanager in this case—was assumed to be part of the overall job, i.e., the employer did not explicitly allocate a specific amount of time to perform this task. The task of preparing risk assessments entails the entire process of making an inventory of substances present at the workplace, gathering data on these substances, prioritizing situations that need exposure assessment, assessing exposure (either by carrying out measurements or by using a model such as Stoffenmanager), evaluating the result, selecting control measures, and estimating their effectiveness.

Some of the participating companies used 100s of products and substances. Thus, the task involved a lot of manual work to fill the database and a large effort related to searching for all the input data needed. Therefore, several companies decided to make use of internship trainees, or temporary workers. Altogether, 58% of the companies visited, explicitly reported that the time investment needed was a major problem.

3.3.2. 'Traceability' of input data

The physical–chemical data of the substances used that have to be entered in the Stoffenmanager model appeared to be hard to find for 91% of the companies visited. This held especially true for

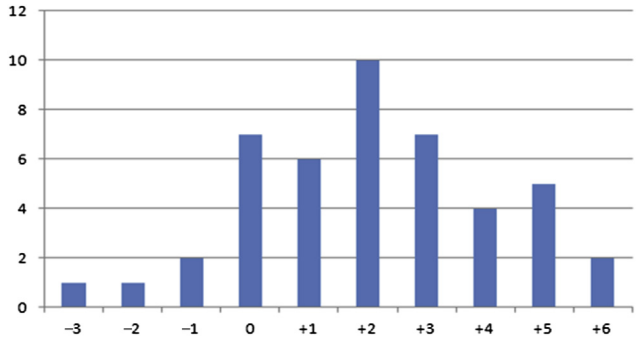

Fig. 7. Shifts in the phase on the Implementation ladder per company; numbers of companies that have made x steps ($n = 45$).

the substances' vapor pressure. Besides, occupational exposure limits (OELs) of the substances were hard to find for 82% of those companies that tried to find them ($n = 28$; 8 of the 36 companies did not try, as they had not made exposure calculations yet at the moment they were visited). As only for ~1,100 unique substances an OEL is available in generally accessible databases, companies had particular problems with finding OELs for the more "exotic" substances.

Although principally, companies should be able to retrieve much of the information needed from the Safety Data Sheets (SDSs) that the supplier provides, when products that contain various components are used, it frequently occurs that vapor pressures and OELs of the individual components are not stated. In fact, five companies explicitly reported that the low quality of the SDSs they received constituted a barrier to them.

3.3.3. Low awareness and low cooperation of workers or purchasing department

In order to prepare reliable exposure estimates, sufficient support from the workers in collecting information on product use and activities carried out is essential. In 57% of the companies visited, this support was judged sufficient by the companies' representative. Similarly, sufficient support from purchasing departments in providing information on products and substances purchased was reported by 63% of the companies.

3.3.4. Little 'guidance' in Stoffenmanager

Sixty percent of the 36 companies' representatives interviewed during the company visits answered that the questions, the structure, and the routing of the Stoffenmanager model was sufficiently clear to them. However, 40% reported to the coaches to have problems determining the 'next step' after preparing a risk prioritization or an exposure calculation. Thus, it seemed that the model structure provided too little 'guidance' to this group of users. Moreover, it was felt problematic that no error reports are given in case of a faulty or missing input.

3.3.5. Little understanding of 'exposure' and of related professional terms

Roughly half of the participants reported to have problems in understanding specific terms and issues that are familiar to exposure scientists, such as distinguishing between a task-based versus a daily average exposure, the influence that the vapor pressure of a substance has on exposure, and the difference between assessing individual components and entire products. In addition, if the company had carried out exposure measurements, they found it hard to understand the reasons why the exposure calculations made by Stoffenmanager deviated from the results of the measurements. The concept of using a 'percentile' value in the model obviously was not instantly clear to all of the participants.

3.4. Success factors

Similar to the barriers described above, information on the success factors that contributed to using Stoffenmanager successfully, and to securing a responsible chemicals' management, have been distilled from the remarks made by companies and the observations made by the coaches during the company visits ($n = 36$). A number of factors that were observed relatively frequently, are described below.

3.4.1. Intrinsically motivated OHS-professional

In 83% of the companies visited, health and safety related to using substances was a top priority for the management and the OHS professional. The importance of having an OHS professional in the company that is intrinsically motivated was explicitly reported by 44% of the companies visited. However, it was the impression of the coaches that in fact, in practically 100% of the cases this seemed to be one of the major factors.

3.4.2. External incentives

External incentives to make a start with preparing exposure assessments and improving chemicals' management as a whole were reported to be a decisive factor by 28% of the companies visited. In particular, visits made by the Labor Inspectorate, and audits held by major clients were reported. In all of these cases, the companies' management provided support to, and trust into the OHS professional in "doing what is needed" to meet the requirements of the Labor Inspectorate or those of major clients.

3.4.3. Stoffenmanager supported by the Labor Inspectorate

In close connection to the aspect mentioned above, the fact that the Dutch Labor inspectorate explicitly recognizes and supports Stoffenmanager as a reliable and sufficiently conservative 'Tier 1' model was regarded very important by 19% of the companies visited. The incorporation of Stoffenmanager as well as a few other models, such as ECETOC-TRA, in the relevant REACH guidance documents provided a further incentive to rely on the model.

3.4.4. Stoffenmanager offers a structure

The simple fact that using a model such as Stoffenmanager provides a manner of getting a 'grip' on the complex issue of implementing a responsible chemicals' management was a major reason to use this model for 28% of the companies visited. Stoffenmanager and similar tools provide a way of getting an 'overview' of the problem, and the model provides validated outcomes, as well as valuable indications for taking control measures.

3.4.5. Database with substance data

Although not yet implemented in the general Stoffenmanager version (by contrast to a few sector-specific versions), 71% of the companies visited would like to have a database that contains basic data on the substances used, such as their vapor pressure and OEL. In these companies it was felt that such a database would make a successful implementation of Stoffenmanager easier. To that end, this is in fact not a 'true success factor' yet, but a 'future' success factor. Those companies that did not wish such a database either did not use many different substances, or had filled their Stoffenmanager database already.

3.4.6. Additional factors

A few additional success factors reported infrequently—i.e., by less than three participants—included: the companies' representative possessing some basic level of knowledge on chemistry, an active sector association that organized an active exchange of information and knowledge, and finally, the support provided by the Stoffenmanager Implementation project itself. The latter factor will be dealt with below.

3.5. Project and process evaluation

In the effect measurement survey by means of telephone interviews among all 45 participating companies, a number of questions were included on the project activities. The participants ranked the five general project activities. Table 3 provides an overview of the activities most valued and least valued by the participants.

It appears that the activities most valued, were those activities in which direct, face-to-face support was provided by the coaches, during the joint training meetings and the company visits. On those

Table 3
Activities most and least valued by the participants ($n = 45$)

	Rank 1#	Rank 2#	Rank 3#	Rank 4#	Rank 5#
Joint training meetings	38%	24%	23%	5%	0%
The opportunity to pose questions at the project website	2%	0%	8,5%	14%	60%
The links and documents at the project website	5%	20%	26%	71%	20%
Personal contact with coach (by E-mail or phone)	17%	16%	37%	10%	20%
Company visit by coach (one-site training)	38%	40%	5,5%	0%	0%

occasions, the companies' representatives were given the opportunity to practice using Stoffenmanager, and to pose questions to the coaches present. Considerably less appreciated were the opportunities to get online support, i.e., the LinkedIn group that was established for mutual support, and the project documents and 'internet links' provided at the project web site.

4. Discussion

To the best of our knowledge and in line with the information in recent papers in this field [12,13], this study was the first in its kind, being a long-lasting (2-year) intervention project, providing active support to a large group (45) of participating companies — most of them SMEs. The project aimed at improving the implementation of Stoffenmanager as well as chemical risk management in a wider sense, and at finding hints to enable the development of tailored support to companies that are willing to optimize chemical management.

It is important to note that the project did not involve a 'representative' sample of the Dutch companies. A relatively 'motivated' subsample of companies was involved, as participation was—obviously—voluntary. Therefore, it was not surprising to see that in a large majority of the participating organizations health and safety related to using substances was a top priority.

In addition, it was decided not to involve a control group receiving no training and support, as one of the major aims of the project was finding the success factors and barriers related to improving substances' management, rather than measuring improvements quantitatively. To this end, the authors feel that the project has provided valuable information that may be used in developing tailored support to companies.

Preparing a general risk assessment, a chemical register and exposure assessments are all legal obligations under the European Union's Framework Directive on Occupational Health & Safety and the Chemical Agents Directive. This may partly explain the relatively high percentages of participants that had done so. However, recent figures from the Dutch Labor Inspectorate show that on average, only 50% of the Dutch companies/organizations have made a general risk assessment, and only ~20% have prepared one or more exposure assessments for chemicals [14]. Thus, the participants seem to constitute a relatively 'advanced' subpopulation of the Dutch companies and organizations. Obviously, the organizations joining a project like this were interested in doing so just because they had become aware of the need for improving their chemical management, and of the opportunities for support that this project offered. This may be less of a problem than one might expect, because we have looked at the 'relative' progress the participants made, each starting from their own position on the seven-phase implementation ladder. Despite this, this fact might imply that a 'random' sample of companies would have made less progress during the project, or would have had even more difficulties with certain aspects of the Stoffenmanager model, although this seems rather speculative.

The seven-phase implementation evolutionary ladder that was developed, was specifically designed to enable assessing the participants' progress in using Stoffenmanager as a tool in improving substances' management. Therefore, although the implementation ladder has not been described in the literature before, it provided a means to assess progress in a well-structured manner and as objectively as possible. It appeared that significant progress had been made by most participants, by comparing their level of implementation at the baseline measurement and at the end of the project.

By means of the effect measurement survey and in-depth interviews and observations during company visits, we identified various success factors and barriers, constituting the reasons for making progress or not making progress. It appeared that the presence of an intrinsically motivated OHS professional in the company was both the main success factor and a main failure factor. The latter will be the case when the OHS professional leaves the company while knowledge transfer is not properly assured. A major incentive for using Stoffenmanager and for improving substances' management in general, appeared to be external pressure such as visits of the Labor Inspectorate or audits by major clients. In case of a visit by the Labor Inspectorate the company should make sure the legal requirements with regard to chemical management are met by a strict deadline. This may shift the focus and the allocation of the means the companies have in order to start this process.

Interestingly, most of the companies (80%) that had measured exposure, had hired external consultants to do so, while most of the companies (76%) that had used models or tools to estimate exposure had carried that out 'internally'. Apparently, using tools such as Stoffenmanager is regarded as something that can be done by SMEs themselves and indeed, the tool has been promoted as such right from its launch back in 2003.

However, the—initially—large time investment needed, and the problems that companies encountered in finding all input data needed on the substances they use, as well as the mistakes made by some companies while using the model appeared to be major barriers to a successful implementation. Although information sources and databases are provided at specific pages within Stoffenmanager it still appeared not straightforward for every participant to retrieve the relevant information, and specific information on more 'exotic' substances could not be found at all in these databases.

Thus, in line with observations made by other authors [12,13], a number of general 'lessons' for model developers and for those supporting substances' management in companies can be given: (1) ensure participation of the "intended user" in model design in order to tailor the model to the needs and capacities of this intended user; (2) provide training, or even more, make training 'obligatory' for future users of the model (e.g., by means of a certification scheme or quality assurance program), (3) provide clear guidance in the model or provide a manual; and (4) organize a platform for continuous support, exchange of experiences and benchmarking, e.g., by means of an 'online community'. Despite the latter recommendation on establishing an 'online community', the evaluation of the current project by the participating companies has shown that the least appreciated activities were the opportunities to get online support. Direct, 'live', and face-to-face support was much more appreciated. Thus, although understandable, it may seem less encouraging that particularly those activities were appreciated that are

relatively very labor-intensive (read: expensive). This seems to remain a challenge and is perhaps a sheer fact of chemical risk management life.

Thus, during a 2-year intervention project, 45 companies were actively trained in chemical risk management by means of the online exposure assessment and management tool Stoffenmanager. Using both a general (joint meetings) and individual approach (site visits), most companies clearly improved on the implementation evolutionary ladder. The main conclusion from this project are: (1) active training and coaching helps companies to improve their chemical risk management; (2) active training and coaching helps to avoid making mistakes when using and applying Stoffenmanager; (3) use of validated tools embedded in a community platform supports companies to organize and structure their chemical risk management in a business-wise manner; and (4) upward movement on the implementation evolutionary ladder largely depends upon motivated OHS-professionals, management support, and willingness to invest time and means.

Conflicts of interest

Cosanta B.V. is the legal owner of the online tool Stoffenmanager.

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