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Intervention Mapping as a Framework for Developing and Testing an Intervention to Promote Safety at a Rail Infrastructure Maintenance Company

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Abstract: In this article, the authors apply the intervention mapping (IM) protocol to develop safety leadership training for a rail infrastructure maintenance company. The IM protocol helps to create an evidence-based intervention in a structured way, based on concrete evidence. The application of IM within the occupational safety domain is limited, a research gap that this article bridges with the development and testing of a safety leadership intervention to promote safety behavior among managers. The company was positively and actively engaged in the training program thanks to the IM protocol. The local support group took full advantage of the opportunities to provide input during the development of the training's various components. Despite this, interpersonal problems within the leadership team itself, such as a lack of psychological safety, were not identified during the needs assessment. These issues had an impact on the overall effectiveness of the training, as they manifested during the training when managers met physically for the first time in several years (due to the coronavirus). Our IM protocol will be adjusted accordingly for future applications, and we hope that sharing our experiences will enable fellow researchers to avoid this problem.

Keywords: intervention mapping; safety leadership; senior managers; prevention research

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1. Introduction

1.1. Background

In this article, we describe how we developed a targeted safety intervention using the intervention mapping (hereafter IM) method [1] for a railroad company that requested assistance with improving their safety after two incidents that could have resulted in serious injuries or train derailment prompted the development of the behavioral intervention.

The number of incidents involving rail track workers in the Netherlands has been relatively low for years. This is an impressive achievement, given that being a track worker was considered to be one of the most dangerous jobs in the Netherlands in 2005 [2,3]. Track work often takes place while trains are running under the protection of lookouts who provide warning of approaching trains. In 2019, no track workers were seriously injured by a moving rail vehicle. Still, worksite safety promotion programs focusing on the improvement of track worker safety remain a necessity to maintain and improve worker safety in the railway construction industry.

A combination of factors affect rail worker safety. Previous studies have demonstrated organizational or technological risk management approaches through the management of safety rules [4] by introducing safe track maintenance schedules [5], tunnel monitoring systems to recognize and detect maintenance workers on the tracks or other technology solutions [6,7], or even digital twins for maintaining a safe working environment for track

workers by reducing the time spent working in the danger zone [8]. Earlier research by Farrington-Darby and colleagues [9] identified 40 factors influencing the safety behavior and safety culture among railway maintenance workers, for example, supervisory presence, peer pressure, managers' communication methods, managers' accessibility and availability, the volume of paperwork, contradictory rules, and feedback messages from managers. They concluded that "the general consensus appears to be that, although the individual does have a part to play, the environment created by the organization (its organizational safety culture and management) largely determines the relevant attitudes, beliefs and perceptions of safety" [9] (p. 58). Railroad workers' perceptions of the safety climate are significantly associated with their safety compliance behavior [10,11].

A more recent meta-analysis by Naweed and colleagues [12] studied track worker safety by specifically examining the risks and (incident) factors involved in so-called lookout working in the UK and Australia. Their study suggested that issues at the organizational and social levels may interact with task- and individual-level factors, and that there was a propensity for co-occurrence in safety-related incidents. Having organizational- and social-level factors alongside individual-level factors increases the overall risk of safety-related incidents. Existing vulnerabilities at the organizational and social levels may migrate to the task and individual levels, creating an increase in the overall vulnerability and risk. The authors concluded that any intervention to improve track worker safety should therefore address the organizational and social levels.

Although their impact has been well documented, few systematically developed interventions focused on improving organizational- and social-level factors in relation to track worker safety exist. Some empirical work has been conducted to assess the influence on track worker safety by improving the safety climate, safety leadership, and safety attitude of railway employees [13–16]. In this paper, we describe our exploration of the IM method to develop a safety leadership intervention structurally. The goal of the intervention is to improve the safety at a rail maintenance company through interventions at the organizational and social levels by training the management and supervisors with regard to their role as safety leaders. In the following section, we briefly describe what the IM method entails.

1.2. Intervention Mapping

The IM method is best known in relation to the development of behavioral programs focused on health improvement. Looijmans-van den Akker and colleagues [17], for example, developed a behavioral intervention targeting the improvement of influenza vaccine uptake behavior among health care workers to reduce the associated health risks. Another example is the study by Oude Hengel and colleagues [18], who developed an intervention at a worksite for older construction workers to reduce their physical workload. However, the method has received fewer applications in other domains, such as the occupational safety domain. The authors are aware of only one study that utilized the IM technique as a means to create an intervention suitable for increasing safety within high-risk industries. This study used IM to develop intervention activities for both business owners (increasing knowledge about machine safety, stimulating the use of safety procedures, and making improvements in machine guarding) and employees (building the knowledge and skills of HSE committee members) in metalworking shops [19,20]. It showed positive findings, like significant decreases in hazards in the workplace as well as increases in safety practices and behaviors. There is also a study in [21] focusing on reducing occupational respirable dust and quartz exposure in the construction industry using an IM approach; this can be seen as a domain related to long-term occupational safety.

IM was developed to structure the development of evidence-based behavioral interventions in the health domain. By means of six iterative steps, a user is guided in recognizing the problem, developing an intervention program, implementing this program, and evaluating its effectiveness. The six steps within the IM method are outlined in Table 1. Each step has clear objectives and end products [1].

Table 1. The six iterative steps when developing an intervention program based on IM. Adapted from figure 1.1 from Bartholomew Eldredge and colleagues [1].

Step 1 Needs Assessment	• Plan needs assessment • Assess health-quality of life, behavior and environment • Assess capacity • Establish program objectives
Step 2 Matrices of performance objectives, determinants and change objectives	• State expected change in behavior and environment • Specify performance objectives • Specify determinants • Create matrices of change objectives
Step 3 Theory-based methods and practical strategies	• Review program ideas with stakeholders • Identify theoretical methods • Choose program methods • Select or design strategies • Ensure that strategies match change objectives
Step 4 Program	• Consult with intended participants and implementers • Create program scope, sequence and material list • Develop documents and protocols • Review available materials • Pretest program materials with target groups and implementers and oversee materials production
Step 5 Implementation plan	• Identify adopters and users • Specify adoption, implementation, and sustainability performance objectives • Create planning table • Write implementation plan
Step 6 Evaluation plan	• Develop and evaluation model • Develop effect and process evaluation questions • Develop indicators and measures • Specify evaluation designs

IM assists researchers in developing theory- and evidence-based health promotion interventions and incorporates the anticipation of program adoption and implementation from the start of the development process. The IM method leads the developer through each of the six steps and results in transparent descriptions of the decisions made or used in the intervention design. The six steps are the following: (1) assessing needs, (2) preparing matrices of change objectives, (3) selecting theory-informed intervention methods and practical strategies, (4) producing program components and materials, (5) planning program adoption, implementation, and sustainability, and (6) planning for evaluation (Table 1) [1]. Throughout the intervention development, there is close collaboration with the target population for which the behavioral intervention is intended and any other stakeholders who may be affected. The steps are followed iteratively and linearly; that is, program makers move back and forth between tasks and steps. The process is also cumulative, meaning that each step is based on previous steps; hence, inattention in one step can lead to mistakes and inadequate decisions later in the process.

1.3. Research Goal

Although the IM method has proven itself in various evidence-based public health interventions and programs, it is still insufficiently known whether it is also effective in other domains, such as occupational safety. Intervention programs within the public health (care) domain that are based on theory, as is the case with methods like IM, are more likely

to be successful than those lacking a theoretical foundation [22–24]. Our goal is to assess the utility of the intervention mapping method for the development of safety interventions in the occupational safety domain. We will do this by applying the method to a real case with an organization that recently suffered two incidents with significant material damage and high potential of personal injuries. In response, this organization requested assistance to improve safety to prevent such occurrences in the future.

2. Methods

At the start of the intervention mapping process, we established a planning group comprising interventionists and researchers from TNO and four coordinators (two managers and two safety staff employees) from the company, who were involved in establishing the content of the program and the intervention strategy at the local level. The safety manager of the company liaised between the management and the researchers and had lead responsibility for the detailed planning of the project within the company. The local coordinators were regularly involved in program planning, reviewing, and testing. The company management agreed upon its own participation in the safety leadership intervention. It would enable and stimulate its main supervisors and safety department to participate in the development and implementation of the intervention during normal working hours.

In the results, we provide a description of the activities performed and the results obtained in each IM step. Throughout this process, the authors were supported by experts in the use of the intervention mapping method focused on health improvement. We made use of various activities during the IM steps, such as the use of interviews to gain insights into the current situation and context of the organization and a literature survey to gather additional scientific evidence on relevant models depending on the topics that would emerge from the interviews. Given the dependence of activities in subsequent steps on results from previous steps, all activities undertaken have been integrated with the results obtained for the relevant IM step in Section 3.

3. Results

3.1. Needs Assessment

During the needs assessment, we gathered information about the direct and latent causes of the two major incidents, the behaviors of the managers and employees involved, and the influence of other social and technical factors, thereby identifying what Bartholomew and colleagues [1] refer to as personal factors and external determinants. For this purpose, both in-depth interviews with employees from various layers of the organization and an exploration of the literature were conducted regarding behavioral elements and relevant intervention types. The interview protocol used can be found in Appendix A.

The interviews were conducted with a selection of both managers and employees—specifically, one general manager, two main supervisors, one head of planning/work preparation, two supervisors/inspectors, one project leader, and four shopfloor employees. An important finding from the interviews was the fact that the (senior) management had a suboptimal role in safety in general and in the occurrence of the two incidents in particular. The management was considered to be out of touch with the actual activities on the shopfloor and should be more attentive to its members' dispersed views in practice on how safety is experienced and handled day to day by workers. A need was formalized for greater visibility of the management on the shopfloor (e.g., safety walks and meetings) and better feedback on procedures that have been and should be undertaken after an incident.

Based on these interviews, a clear picture emerged that the company would benefit from an intervention aimed at improving safety leadership. The management recognized that it must take the first step to be able to influence safety behavior positively in the workplace in a sustainable way. The decision to focus on the importance of safety leadership was supported by the coordinators of the program and is in line with the existing literature

on this topic, since leadership is critical to the creation of a work environment in which people can demonstrate dedication, trust, and competence to put safety into practice as their organization intends [25,26]. An additional systematic search for scientific literature on safety leadership was performed, since the results of the interviews suggested that the safety leadership of senior- and mid-level managers appeared to make a significant contribution to safety incidents; that is, they were considered to be an important context determinant. The Scopus database, which contains all the important journals in the field of occupational safety, was used, employing keyword combinations relevant to safety leadership (e.g., safety leadership, (employee) safety behavior, team leader, and (middle) manager). In this exploration, the researchers limited themselves to important leadership styles and behaviors in relation to safety within various high-risk industries to create a more robust evidence base, since leadership studies in the rail sector alone are rather limited. Defining leadership is not a trivial matter, according to McCleskey [27], who stated that the "correct" definition best fits the specific intentions of the user. However, definitions of leadership generally have a number of characteristics in common:

1. A leader has collaborators or "followers," which usually means that the leader has formal power (although this need not be the case, as there are informal leaders with followers as well);
2. The leader influences their employees with their behavior;
3. The influence is aimed at jointly achieving certain organizational goals; in the case of safety, these are, of course, safety objectives.

After screening articles by title and abstract, further screening was based on (1) publications that were based on a theoretical model; (2) publications in which the relationship between leadership and occupational safety was investigated or the article described training for leadership in safety; and (3) studies that were conducted in industry or construction. The final selection contained 29 publications, which were read in full. A complete review of the scientific literature on this topic is beyond the scope of this section and approach. Nevertheless, in short, it can be stated that various studies have shown that different leadership styles, mindsets, and, more recently, leader behaviors have their own unique influence on safety performance, for example, safety compliance and safety participation [16,28–33]. Table 2 gives some examples of concrete leadership behaviors affecting safety performance as identified in the literature included in our review. Figure 1 summarizes the key concepts or determinants in the literature that we have studied in relation to safety leadership and the outcome variables that they are supposed to influence as stated in the reviewed publications, specifically safety motivation, compliance, participation, and so on (see the column on the far right-hand side).

Table 2. Concrete leadership behaviors affecting safety performance.

Paper	Related Leadership Theory	Example Leadership Behaviors
[28]	LEAD model	- Leverage: gives positive recognition when the team performs tasks safely and sets clear and specific health and safety goals. - Energize: visits workers on this team to talk directly with them about health and safety; encourages the team to ask questions and clarify health and safety messages. - Adapt: thoroughly investigates the situation when a health or safety incident happens. - Defend: compliance with health and safety rules is enforced; workers' safety performance is closely monitored and supervised.
[29]	Transformational	- Shows interest in subordinates' personal and professional development and listens to followers' needs and concerns. - Challenges assumptions, takes risks, and encourages subordinates to be creative.

Table 2. *Cont.*

Paper	Related Leadership Theory	Example Leadership Behaviors
[29]	Transactional	- Recognizes which actions subordinates must take to achieve outcomes. - Clarifies role and task requirements so that subordinates are confident in exerting the necessary efforts to fulfill leader expectations.
[34,35]	Empowering	- Providing positive emotional support by recognizing good work and taking care of the members' welfare. - Promoting subordinates' self-effectiveness and increasing the feeling that they can accomplish the task.
[36]	Leader–member exchange	- Promoting more open and frequent communication and feedback (related to safety).
[33]	S.A.F.E.R. model	- Speaking about safety, Acting safely, Focusing on safety, Engaging others in safety initiatives, and Recognizing safe performance at work.
[37]	Leadership behavioral orientations	- Production orientation: dares to make decisions based on intuition; dares to make decisions. - Growth orientation: encourages employees to voice their opinion; ensures that the necessary improvements are made. - Relation orientation: can listen well, supports, and encourages. - Dominance orientation: sometimes comes across as hostile; avoids involvement.

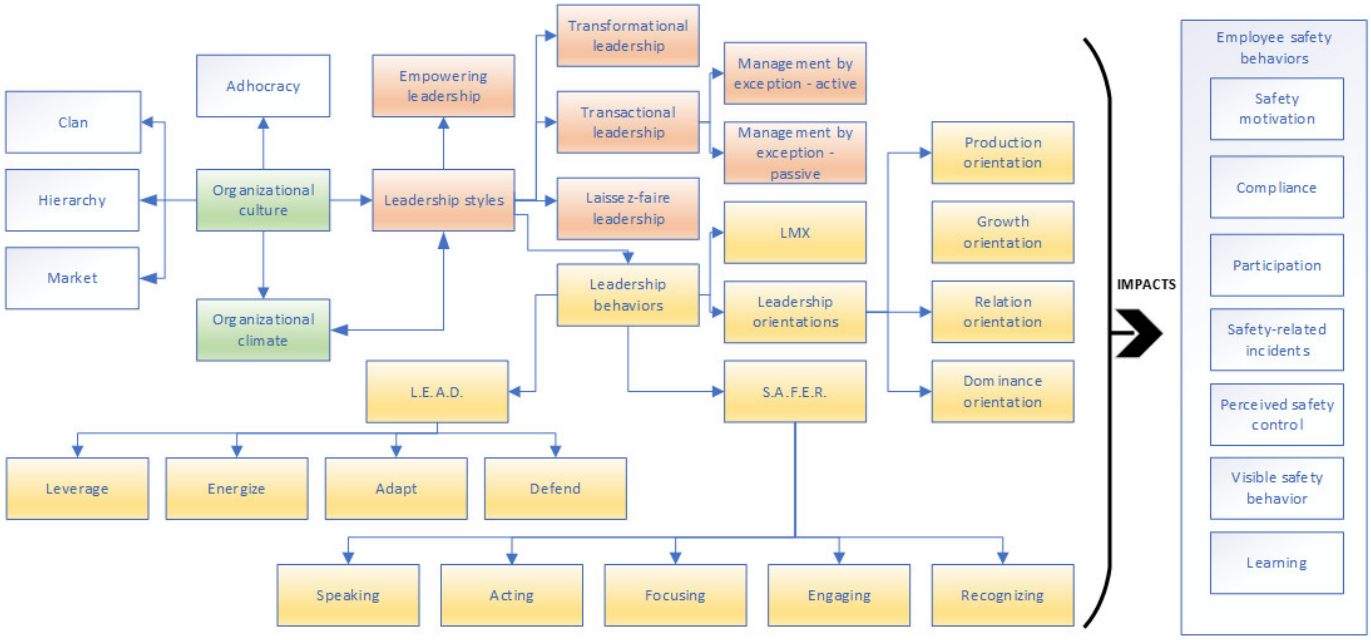

Figure 1. Key safety leadership determinants and related outcome variables.

From the key determinants and general characteristics of safety leadership in the literature, it can be concluded that the influence of the leader (i.e., manager or supervisor) on safety in terms of accidents or injuries always either runs indirectly through other determinants or constructs, such as the safety behavior of employees (compliance or participation), their attitude or motivation, or their empowerment, or it is moderated by the safety climate (the perceived priority of safety). To some extent, this is also obvious because, between the leader and the incident or accident, there are usually one or more employees over whom the leader exercises their influence.

3.2. Preparing Matrices of Change Objectives

In the second phase of IM, the result of the needs assessment is translated into concrete change objectives. This is achieved by first specifying the performance objectives and identifying the underlying behavioral determinants that the program needs to target to achieve the desired changes. Based on the needs assessment, two program objectives are defined by specifying what and who needs to change to improve the safety leadership: (1) managers update their awareness of the importance of safety leadership behavior, and (2) managers improve their actual safety behavior. For both of these program objectives, several specific performance objectives were identified:

Program objective 1—managers:

- Feel responsible for performing work safely;
- Give safety greater priority during management decision making;
- Make the conscious decision to work safely all the time;
- Eliminate unfavorable working conditions (physical workplace and social context) for safety.

Program objective 2—managers:

- Show up more often in the workplace and are approachable to employees;
- Set a good example with their own safety behavior;
- Act proactively on and disseminate lessons learned from incidents;
- Motivate employees to work safely as well as supervising them;
- Create a psychologically safe (learning) climate in which people feel encouraged to discuss operational deviations openly and to report and discuss concerns or encountered problems without fear of retaliation.

The behavioral determinants underlying these objectives were based on our findings from the literature and the interview results. We merged the five most commonly used theories of (health) behavior change into an integrated model, following Fishbein [38] and Fishbein and colleagues [39], containing elements of the Health Persuasion Model, Social Cognitive Theory, Theory of Reasoned Action, Theory of Self-Regulation and Self-Control, and Theory of Subjective Culture and Interpersonal Relationships (Figure 2). This model combines the most commonly used theories to effect behavior change into one coherent behavioral theoretical framework, which forms the so-called "theory of change" of our leadership intervention. The model depicted in Figure 2 includes all the determinants that can affect behavior change: (1) awareness, (2) attitudes, (3) social norms, (4) self-efficacy, (5) skills and knowledge, (6) intentions, and (7) environmental barriers. Although this model derives primarily from academic work focused on health behavior change and has not yet been applied to occupational safety-related behaviors, there is a precedent to expect them also to influence safety behavior change and possibly to regulate and predict change in injury risk prevention behaviors in many settings, including the workplace [22]. This model has been independently validated by an expert from a relevant department from TNO, with expertise in the field of behavioral change and intervention mapping.

Being aware of the problem (1), having a strong positive intention (6), and possessing the necessary knowledge and skills (5) to perform the required behavior (8) combined with experiencing no or limited environmental barriers (7) to doing so are considered necessary and sufficient to produce a safety-enhancing behavioral change among leaders (8). Attitudes (2: believing that the advantages of performing the new leadership behavior outweigh the disadvantages), social norms (3: perceiving more social pressure to engage in the leadership behavior than not to perform this behavior), and self-efficacy (4: leaders perceiving themselves to be capable of performing the leadership behavior under different circumstances) can weaken or strengthen a behavioral intention.

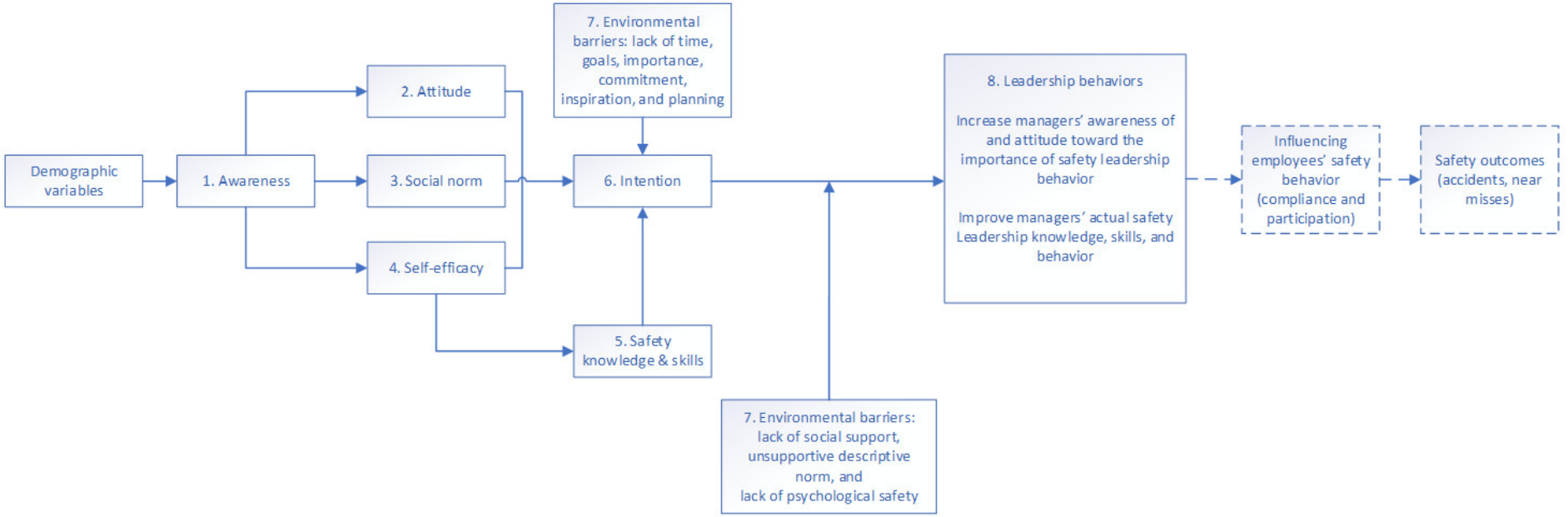

Figure 2. Theory of change model: behavioral determinants for changing safety leadership behavior.

Here, determinants 2 to 5, which affect the formation of intention and environmental barriers (7) that may prevent the formation of intention (such as no or insufficient time to perform the behavior) or the translation from intention into behavior (e.g., no support from the environment to perform the behavior) must be considered. Further, the assumption is that if a person has the intention to exhibit certain leadership behavior and has the right skills to exhibit the desired behavior, the likelihood of them actually exhibiting the desired behavior increases. As discussed previously, in line with other safety leadership research, it is expected that improving the safety leadership of managers will have a positive effect on employees' safety behavior (i.e., safety compliance and participation) and, ultimately, on safety outcomes (i.e., incidents and accidents). These boxes are dashed in the model, as they are not the primary focus of this study.

Based on the discussed determinants, the identified objectives were transformed into concrete change objectives (see Table 3). Taken together, these change objectives should ultimately lead to an improvement in safety leadership behavior in terms of setting the right example and creating a favorable social environment in which track workers themselves are motivated to work safely, modeled on safe working.

Table 3. Relationship between identified objectives, theoretical determinants, and concrete change objectives.

Program Objective 1: Increase Managers' Awareness of the Importance of Safety Leadership Behavior		
Performance objective	Determinant	Change objective
Leaders make the conscious decision to work safely all the time.	Awareness	Leaders see the benefits of working safely.
Leaders feel responsible for the safety of operational activities.	Attitude	Leaders are able to take responsibility for their safety-related work.
Leaders prioritize safety over other decision priorities.	Attitude	Leaders believe that prioritizing safety is important and benefits production and quality.
Leaders eliminate unfavorable working conditions.	Knowledge, environmental	Leaders realize that they can exert control over characteristics of the physical work environment and social context that diminish the level of safety for employees.
Program objective 2: Improve managers' actual safety behavior		
Performance objective	Determinant	Change objective
Leaders show themselves frequently (daily) in the workplace and are approachable.	Knowledge and skills	Leaders know what happens in the workplace, and vice versa. Leaders have open communication/dialogue with the shopfloor employees.
Leaders inform and involve the shopfloor repeatedly with regard to safety matters (incl. incidents).	Skills	Leaders consult the workplace about safety issues.
Leaders set a good example (follow the safety rules and procedures set by the company).	Social norm	Risks are avoided, and risk-reducing measures are taken. Leaders walk the talk; leaders do what they say.
Leaders motivate employees to work safely.	Skills	Leaders inspire employees to participate actively in safety initiatives and make suggestions for improvements for working safely.
Leaders promote a joint, unambiguous, inspiring vision and plan with regard to working safely.	Environmental	Leaders develop an inspiring vision and policy plan with regard to safety without conflicting messages.
Leaders draw up (personal and group) action plans to improve their own safety leadership behavior and provide each other with regular feedback on progress.	Self-efficacy, environmental	Leaders are prepared to translate their own exemplary role into concrete action plans at the personal and group levels.
Leaders give employees and each other feedback on safety-critical behavior.	Social norm, skills	Leaders hold each other accountable for safety behavior. Leaders dare to ask each other questions. Leaders create and maintain a psychologically safe atmosphere. Leaders are familiar with safety-critical behaviors.

3.3. Selecting Theory-Informed Intervention Methods and Practical Strategies

In this step, the theoretical methods and strategies necessary to achieve the change objectives formulated in the previous step were identified. A theoretical method describes the association between an intervention action and a change in the identified individual and environmental determinants. Thus, theory-based methods should improve workers' abilities and the environmental opportunities to act effectively on their motivation or intentions.

The identification of the most promising theories and strategies was conducted by means of the review in [40], which provides various behavior change techniques in relation to different behavioral determinants as addressed in this research. These change methods were translated into practical strategies customized to the aim of this intervention to accomplish a successful shift from motivation to change safety leadership behavior into actual behavior change. Finally, the resulting evidence base in terms of theory and the behavior change strategies for the intervention were discussed and selected together with the local coordinator group. These practical strategies were formulated as program components; see Table 4 for an overview.

Table 4. Behavior change methods and program components for each determinant.

Determinants	Behavior Change Methods	Program Components: Selected Training, Tools, and Materials
Awareness	Discussion, consciousness raising, organizational diagnosis, and feedback	Company-wide survey and discussion of survey results by trainers with the entire management for an up-to-date understanding of the state of workplace safety and evaluation of their leadership behavior by employees as the start of change.
Attitude	Participation, framing to shift perspective	Invitation sent out to all managers by the management requesting that all attend the training. The reason for the training is contextualized by reference to previous incidents and the desire for improvement in safety leadership at the management level.
Social norm	Evaluation of own person and environment	To encourage cognitive and affective assessment of one's own and fellow leaders' actions in terms of safety leadership and raise awareness of the need to act as role models for employees in the organization.
Self-efficacy	Planning coping response, expressing public commitment, setting goals, intentions for implementation	Personal and group action and coping plans (i.e., what to do in the case of setbacks in behavior change) are drawn up that are feasible and realistic (SMARTI-formulated: Specific, Measurable, Acceptable, Realistic, Time-bound, and Inspiring). Individual commitment and intention are expressed to each other during the training in the group to make a personal effort and work toward behavior change, and possible obstacles are discussed to overcome them.
Safety knowledge	Discussion, raising awareness	The leadership training starts with a theoretical part that addresses the importance of safety leadership, leadership models, and concrete behavior of safety leaders, followed by a group discussion on safety leadership in the organization.
Skills	Modeling, facilitation	Appropriate role models within the group are shared and discussed with each other and reinforced for the desired (identified) safety leadership behavior in practice, i.e., leaders walk the talk, are present regularly on the shopfloor, interact with employees for information about safety issues, stimulate employees to participate in safety initiatives, and promote safety compliance in a psychologically safe environment.
Environmental barriers	Facilitation	The company management agrees upon its own participation in the safety leadership intervention and stimulates the team supervisors and safety department to participate in the intervention during normal working hours. Unfavorable working conditions for employees, as identified during the interviews, are addressed outside of the training by the management. Psychological safety within the management team is addressed and discussed by trainers during the training. The safety manager makes sure that individual- and group-level plans after the training are discussed at every management meeting, which gives managers the opportunity to discuss results and strategies for improving their leadership behaviors. Furthermore, the safety manager makes the actions formulated in these behavior change plans a structural part of the PDCA cycle of the safety management system for regular monitoring (for progress on behavioral change and outcomes) and adjustments if necessary.

3.4. Producing the Final Program and Materials

In this fourth step, the formulated program components were combined into a single intervention program targeting the executive and middle management of the rail maintenance company. First, we collected the available existing intervention materials addressing the improvement of rail worker safety [41]. A brainstorming session was conducted be-

tween the local coordinator group and the experts to translate the outcomes of step 3 into a final program plan. In addition, the plan was developed in more detail with one researcher specialized in combining and developing intervention components. If existing intervention materials were not available or were not tailored sufficiently to the railway sector to meet one or more change objectives, then new materials were developed to cover all the necessary change objectives. Finally, a meeting with the coordinators was organized to discuss the program plan and the implementation of the developed intervention: safety leadership training.

With regard to program objective one (managers update their awareness of, knowledge about, and attitude toward the importance of safety leadership behavior), a safety leadership training session of one day was developed. First, a tailor-made leadership survey, based on an existing Dutch questionnaire, was used to identify the companywide perception of all the employees and management of the current safety leadership behavior. This survey was used as a pre- and post-intervention measurement instrument (see Results Step 6 for more detailed information). The results of this assessment were analyzed before the training session and presented during it to facilitate a discussion, giving participating managers insights into how the rest of the company views safety and how their own behavior contributes to it.

The main goal of the training was to make managers and supervisors within the company aware of the importance of being safety leaders. The training emphasized the need to put safety first in everyday operations in every decision made and created awareness of the fact that the leaders can exert a positive influence on the attitude of employees and teams toward working safely by acting as a role model for safe working. Finally, it emphasized that managers are in the prime position to exert control over unfavorable working conditions for employees by removing or solving problems related to planning, tools, materials, and so on necessary to perform the work safely. A crucial part of the training is the explication of the safety ambitions and the vision on working safely by the management first. The input for this was theory from the scientific literature and the companywide perceptions obtained through the survey. Improving one's own leadership skills was made concrete in the training by drawing up individual and team action plans to improve safety leadership within the company in the coming year. After the training, each participant had a clear idea of what safety leadership entails and how they can improve it individually or for their own department/organization.

The one-day training had a modular structure, and the following training tools were used:

- Presentations with supporting material, illustrated with case studies;
- Interactive dialogue with and between the participants and group work sessions led by the training facilitators;
- Drawing up a (personal) action plan to improve safety leadership within the company in the coming year, reinforced by each participant expressing their personal commitment to the plans;
- Planning feedback sessions (coaching) on progress and institutionalization plans by uptake in regular work meetings/activities and the PDCA cycle.

We ensured that the intervention format took into account the factors essential for the adoption, implementation, and maintenance of behavior change and institutionalization to ensure that old habitual behavior is actually broken in time, and that the chance of relapse (due to environmental barriers, see Figure 2) in the medium to long term is reduced by anticipating any undermining (organizational) goals.

A core element of the resulting intervention was aimed at helping supervisors and managers to formulate behavior change action plans to improve their own safety leadership (program objective 2). To facilitate accurate and realistic behavior change action plans, at the start of the training, the trainers provided the training participants with written guidelines in a training folder in which all substantive and practical assignments related to the modules were included as background information. More specific information

with regard to formulating good and realistic behavioral change plans can be found in Appendix B.

3.5. Implementation Plan

This step is the culmination of the previous steps in which all the elements identified are put together, an implementation strategy is formed to ensure that the intervention is implemented effectively, and the formulated goals are met. Appendix C gives a detailed description of the different change methods and practical applications used to enhance the adoption of the training at different stages before its actual delivery and to promote the maintenance of behavior change and the institutionalization of the training results.

A protocol was developed, including a plan for the implementation of the intervention program, and was written down by the researchers together with behavioral change experts. This protocol contained the content of the training (e.g., the agenda, training modules, goals, and method per training module), the organization of the program, and the communication between all the stakeholders involved (e.g., workers, trainers, researchers, and managers). Moreover, the protocol aimed to standardize the training session across the two trainers. The training itself was delivered at an external location arranged by the company itself. This was a conscious choice to separate the managers from their regular work environment to facilitate problem solving and openness to change.

The intervention was carried out, and the managers and supervisors were given the necessary knowledge, skills, and tools to improve their safety leadership behavior. Since all the participants formulated a personal action plan and expressed their commitment to this plan in their peer group of managers en plein publique, the intention to actually change their behavior was reinforced.

However, unexpected interpersonal dynamics surfaced during the training program between various managers from different organizational levels of the participating organization. It turned out that a lack of psychological safety had already been present within the group for a while and prevented managers from aligning their ambitions and group plan properly during our interactive workshop as part of the training. These dynamics gave an indication that certain elements within our IM approach need to be addressed accordingly, that is, explicitly targeting psychological safety within and between management layers in the needs assessment and local planning group. Psychological safety was addressed in this study but as part of management providing a safe environment for employees to report incidents and problems and as part of a safe working environment within shopfloor teams for speaking up about ideas, questions, concerns, or mistakes. Psychological safety within and between management teams specifically appeared to have been a blind spot here.

Moreover, before the safety leadership performance objectives could be fully established within the participating company, it was decided to time out the implementation process and first organize separate training to solve the interpersonal issues arising from the lack of psychological safety within the management team. Survey data from McKinsey [42] have indeed indicated that fostering psychological safety throughout an organization begins with its most senior leaders developing and embodying the leadership behaviors that they want to see across their organization, stating that "many of the same skills that promote positive team-leader behaviors can also be developed among senior leaders to promote inclusiveness." This can be achieved by, for instance, developing open-dialogue skills and social relationships within teams as important skill sets for senior leaders.

3.6. Evaluation Plan

In the final step, the researchers made the necessary preparations to evaluate the implementation of the intervention and determine whether it was successful in achieving the established objectives. As a result of the unexpected interpersonal dynamics described in the previous step, the evaluation of the program was postponed until after additional steps had been taken in the program to address the lack of psychological safety. As an additional objective, during the evaluation, we will explore how this issue remained hidden

during the earlier IM steps taken, control for the influence of psychological safety within the management team, and consequently determine which steps would need to be included in addition to the already-taken IM steps to prevent this problem from happening in future projects.

The evaluation of the program will be undertaken on the basis of the tailor-made survey developed in the fourth step. Measurements will be performed at the baseline (pre-test before the training) and 12 months after the start of the intervention (post-intervention mid-term follow-up). The primary study's outcome objectives are improvements in actual safety leadership behaviors. Improvements in the safety behavior of track workers (i.e., safety participation and compliance) are defined as secondary outcomes.

The intervention targeted awareness, attitude, social norms, safety knowledge, and safety leadership skills while taking environmental barriers into account. All the participants created behavior change action plans demonstrating their intention to change their behavior. Whether the safety leadership of the managers actually improved over time will need a follow-up measurement, which is currently still a work in progress.

Further studies on the effect of OSH interventions are strongly warranted, since only limited evidence is available for the effects of common interventions like OSH training on reducing injuries and fatalities [43]. Leadership development interventions in particular are difficult to evaluate, because their effects are often indirect and delayed. Schwatka and colleagues [44] concluded that the evaluation period of their FSL training may have been too short. In most studies, effect measurement is only carried out months later. This gives leaders time to integrate the key concepts presented in leadership training into their daily practice as well as allowing their employees to observe these changes in leadership factors. Therefore, a formal effect evaluation in this study will be undertaken 12 months after the training.

Moreover, Mullen and Kelloway [45] suggested that combining education (e.g., leadership training) with personal continuous feedback requires a lead time of at least 1 year to create and promote the maintenance of safety leadership practices. For this reason, it was decided to include additional coaching by the trainers within 3 months of the training (short-term follow-up) as an option to check the progress in the implementation of the personal and group action plans that the managers made during the training.

4. Discussion

The goal of this exploratory research was to examine the usefulness of the IM stepwise approach to evidence-based intervention development in the occupational safety domain in general and in the railway sector more specifically. We described the development of an evidence-based safety leadership intervention with both new and existing materials by using the intervention mapping framework for planning a safety promotion program. This program was tailored specifically to the situation of the participating rail maintenance company that requested assistance to improve safety to prevent the re-occurrence of recently suffered incidents. We identified important and changeable determinants of safety leadership behavior, specified change objectives for the intervention program, selected theoretical change methods for accomplishing the intervention objectives, and finally operationalized change methods into practical intervention strategies. Throughout this process, the authors frequently discussed the progress with experts in the use of the intervention mapping method focused on health improvement.

The main attraction of this method is that the IM step-by-step approach forces the intervention developers to consider not only the identified safety behavioral problems but also the underlying organizational context of these behavioral problems to produce an effective change intervention together with the target group of the behavioral intervention. OSH interventions are often wielded as hammers, and the problems of various organizations may appear to be similar nails to be solved with any hammer. Instead, the IM method systematically incorporates empirical findings from the literature, behavior change theories and methods, and input from the company stakeholders though all its steps, thereby devel-

oping an intervention that is customized to a specific context of workers, supervisors, and employees—in this case, the railway maintenance industry. As a result, the intervention program is better suited to the specific situation within an organization and, through the participation of the target group and other relevant stakeholders in each IM step, increases support for the actual implementation of the intended behavioral change. The training is in fact fully customized to the organization as opposed to using more standard safety leadership training. The assumption is that this also significantly improves the effectiveness compared with more standard training formats. Of course, this still has to be determined here after 1 year of following the training with our evaluation method.

The disadvantage of the method is that it is time-consuming. Safety leadership behaviors like those described in this study are mostly multidimensional due to the determinants at different levels, making IM a time-consuming process. The entire process of IM in the present study effectively lasted around 6 months. However, the study results lay the foundation for leadership training in other organizations in terms of identified behavioral determinants, change goals, and practical change strategies. Indeed, the expectation and experience of the intervention developers is that similar aspects are at play in other organizations within high-risk industries. Customized leadership training for other organizations can be set up relatively easily based on the currently developed intervention. That being said, a thorough behavioral analysis must be performed for each organization separately to address the relevant nuances and areas of concern adequately within the particular company. In future research, we could be more efficient by starting with our survey of the target population and managers based on our current insights into which determinants define good safety leadership instead of beginning with in-depth interviews regarding safety incidents, which was the starting point here. This approach could lead to a shortlist of specific topics as the start of the needs assessment, and subsequently, fewer focus groups with the local planning group will probably be needed in steps 1 and 2 of IM.

It should be noted that, ultimately, technical solutions in line with the Public Health Hierarchy of Hazard Control, whereby interventions that are more effective in preventing accidents eliminate risks at the source of the hazard through technical solutions or the separation of workers from hazards, will achieve the greatest improvement of occupational safety [46]. Simple engineering controls are possible and easy to implement. One example of such technical intervention in the participating company besides the leadership training is the procurement and deployment of light beacons on the track during maintenance work, especially when adverse weather conditions, such as fog or rain, cause materials to be lost from employees' sight (a contributing factor in one of the mentioned incidents that sparked the initiation of this intervention's development). A combination of both organizational and technical solutions will best optimize the safety of rail track workers. Recent results from Dyreborg and colleagues [46] show strong evidence supporting greater effects of safety interventions directed toward the group or organization level rather than individual behavior change and of multifaceted approaches combining intervention elements at different levels (human, organizational, and technical). In addition, modest effects were observed for interventions using techniques such as leadership training to improve safety communication. Furthermore, the research by Van Kampen and colleagues [47], carried out among Dutch safety professionals, indicated that leadership training focusing on safety roles is frequently undertaken and is perceived as having high effectiveness, actually appearing among the top three interventions considered to be effective. In line with these results, the current study also focused on improving safety leadership alongside technical interventions. Pending the study results, it remains to be seen whether this also improves the actual safety (behavior) of rail maintenance managers and workers.

Intervention mapping helped us to develop a systematic safety leadership intervention with a clear link between behavioral goals, theoretical methods, practical strategies, and materials and with a strong focus on implementation and recruitment. However, there are some limitations to the method, and during its implementation, we often encountered obstacles that we would handle differently next time. For instance, relying solely on

the company's proposal, it was decided for efficiency reasons to work primarily with executives as participants in the local planning group for involvement in steps 1 through 4. The agreement was made that they would coordinate internally (without our involvement) with the team leaders on the choice and content of the final intervention. This did indeed take place as such based on our preparatory input for such internal alignment sessions, and we understood that the middle management was on board with us. Because board members volunteered to participate in the project, it is plausible that they were early adopters [48] of safety leadership training. However, this might have caused us to miss important information on constraints and worries about such an intervention from the middle-management level that was not aired by them or communicated to us by the local planning group. Instead, we should involve members from this organizational level next time to control for this potential issue.

Furthermore, because of time constraints, it was impossible to perform the intervention within the 6-month program. Instead, sample materials of the training were tested with the local coordination group via a videoconferencing presentation in step 4 of the IM, and parts of the training were adjusted to its members' needs.

5. Conclusions

In the paper, we set out to assess the utility of the intervention mapping method for the development of safety interventions in the occupational safety domain. We conclude that the IM method can be used by safety professionals to develop safety interventions in a systematic manner. The use of IM and the involvement of the local planning group in the development of a worksite prevention program proved to be useful, tailoring the intervention not only to the needs of the target population but also to the abilities and opportunities of the implementers. The present study also gives deeper insights into the current theoretical and empirical knowledge in the field of improving managers' safety leadership in the railway maintenance industry. Therefore, the next step, in which the first evaluation will be performed, will be taken with great confidence in the overall design of the intervention program.

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Appendix A

Appendix A.1 In-Depth Interview Protocol

Interviews were held to identify the behavioral causes of two major railway incidents at the end of 2019:

1. An incident with a measuring trolley that came into contact with a high-speed train;
2. An incident in which the rail switch was put in the wrong position and then broken by a lorry.

The goals of the interviews were to gain insights into:

(a) The behavioral causes of the two major incidents at the end of 2019;
(b) The behavioral determinants that are relevant in this situation;
(c) The intervention options that can be used to prevent these types of incidents in the future.

Eleven participants with the following functions took part in the in-depth interviews:

- One general manager;
- Two main supervisors;
- One head of planning/work preparation department;
- Two supervisors/inspectors;
- One project leader;
- Four shopfloor employees.

The mean age of the interviewees was 44.64 (range = 26 to 58 years). The number of years working for the rail maintenance company was, on average, 7 (range = 2 to 12.5 years). The involvement in the two incidents mentioned earlier was as follows:

- Eight participants were not directly involved in but were aware of one of the incidents;
- One participant was directly involved in one of the incidents;
- Two participants were indirectly involved in the incidents.

An interview protocol was designed to obtain relevant information regarding the behavioral causes of the two major railway incidents and information on how to prevent such incidents from happening in the future. Some background questions were asked:

1. What is your age?
2. What is your position within the company?
3. How long have you been working for the company?

Then, the interview protocol was split into two different sections. Depending on whether the employee was actually involved in the aforementioned incidents, a different question set was used. If the interviewee was involved in the incident, they were asked to report their own experience of what exactly happened in the situation of the incident(s). Based on preceding interviews with the client company, the following specific topics were addressed within the interviews:

- Causes of the incident(s);
- Formal roles of involved colleagues in the job performed;
- Job description, responsibilities, and job feasibility at the time of the incident(s);
- Motivation for safe working (related to the fast and effective delivery of work) and risk perception (estimation of the chance that an incident will take place under their leadership or that of one of their colleagues and why);
- Openness, atmosphere, and culture amongst managers and colleagues;
- Prevention of future incidents:
    - To what extent is the interviewee concerned about these kinds of situations in the future, and why?
    - What do they need themselves to avoid these kinds of situations, and why?
    - What do they expect from their colleagues or their own team, and why?
    - What do they expect from their manager(s) in this regard? What do they expect from other managers? Why?
    - What else do they need to avoid such a situation in the future?
    - What are the possible barriers to prevent such a situation in the future?

All the participants received a debriefing on these research goals beforehand, had to give their verbal informed consent (for participation, for recording the interview, and

for use of the anonymized interview data), and were guaranteed anonymity; that is, it was made clear that the managers of the interviewees would not receive any information other than the general conclusions from the interviews. The company itself sent the project introduction by email and scheduled interviews during working hours. It made an online webstore voucher of EUR 20 available for each interviewee after participation. The interviews were recorded for the purpose of analysis, and, after the final report had been made, the recordings were destroyed.

A qualitative analysis of the interviews was performed with the safety influencing factors identified by Farrington-Darby and colleagues [9] in mind as potential categories. The interview transcriptions were coded and classified into categories of influencing factors associated with rail workers' safe and unsafe behavior (e.g., weather conditions, tasks and responsibilities, procedures and rule breaking, safety knowledge and training, safety leadership, psychological safety, communication, group norms, risk perception, incident management, and risk perception).

Appendix B

Appendix B.1 Instructions for Achieving the Desired Behavior Formulated in the Action Plans

To support the drawing up of the action plans at the group and individual levels, explicit rules were given to increase their quality, inspired by Tiggelaar [49]. For instance, the strategic and behavioral goals that the managers should set during the training have to be challenging but not too difficult given their existing skills and situation. They are requested to check whether a formulated objective is measurable, active (what they WILL do), and personally formulated. The goals are formulated to be SMARTIO, that is, Specific, Measurable, Acceptable, Realistic, Time-bound, Inspirational, and Own control. The last one means that when a manager depends on others to achieve a certain behavior goal, they need to involve those others quickly and effectively. Below, more specific guidelines to formulate the desired behavior in the action plans are given.

Table A1. This is a table. Tables should be placed in the main text near to the first time they are cited.

Principles
1. Formulate behavior positively (what the participant wants to achieve or is going to do instead of what they do not want to do anymore). 2. Formulate a concrete "if–then plan" (so-called cue–trigger response) linking a concrete situation to concrete behavior (if situation X occurs, I will do Y). For example, every Monday morning at 07:30, I will make my work visits, then I will drive to work location X/Y or Z, and I will actively discuss safety with my employees, and I will give at at least one compliment. 3. Formulate for yourself the two most important benefits of the new behavior (in the example above, performing weekly work visits). 4. Check whether you have formulated the desired behavior sharply enough (SMARTIO) by asking yourself the question: what are you going to do for that? NOT: I will make more work visits BUT: I will make a working visit every Monday at one location between 9 a.m. and 10 a.m.
Additional advice
1. Anticipate difficult situations: a. By pre-determining supportive/counter behavior that helps to perform the desired behavior in the difficult situation. For example, what will the managers do when they are busy or stressed? b. Break through inertia by addressing conscious and unconscious obstacles that prevent you from turning your good intentions into new (habit) behavior; think of: - Persistent habits (often moving the round on the floor in your agenda or not doing it at all); tip: make new behavior concrete (SMARTIE) and personal; - Negative environmental influences ("other managers do not do it either," "employees do not want to be checked"); tip: think about what you need from fellow managers or your employees to achieve your goals; - Lack of the right knowledge and/or skills ("how exactly do I motivate employees to work safely?"); tip: formulate an education, coaching, or training wish, practice with a colleague manager, exchange ideas and success stories with each other;

Table A1. *Cont.*

- Low self-confidence ("we have tried to talk to employees about working safely but that has had little effect"); tip: ask for support from someone you trust and who can really help you with the problem (choose a buddy).

2. Testing change plans for various forms of self-deception.
3. Emphasizing the importance of and giving tips to motivate, giving feedback, and rewarding each other during the behavioral change.
4. Emphasizing the importance of and giving tips for self-monitoring (e.g., keep a daily diary regarding activities performed on the formulated behavioral goals) and adjusting action plans in the meantime based on lessons learned and positive or negative experiences.

Appendix C

Appendix C.1 Description of Different Change Methods and Practical Applications Used To Enhance the Adoption of the Training at Different Stages before Its Actual Delivery

Table A2. Theoretical change methods and practical strategies regarding the adoption and maintenance phases.

Phase	Determinant/Change Objective	Theoretical Change Method	Parameters	Practical Applications (Tools, Materials)
Adoption	Institutional commitment M decides to roll out leadership training.	Public commitment	Decision at a meeting to start intervention by T	M ratifies the initiative by signing the decision during a formal meeting. Email from M to W to promote participation in training and questionnaire research.
Adoption	Institutional commitment M makes resources (time, resources, facilities) available for the training and the execution of the action plans afterwards.	Facilitation, obtain formal commitment	M and T identify barriers and enabling conditions, power to implement required changes lies with M Written commitment from M indicating what they will do to implement the intervention	M determines how much time can be spent on the trajectory. M makes financial resources available for the implementation of the training. M ensures that material facilities (space, equipment, etc.) are available.
Adoption	Strong organizational leadership M understands the importance of strong leadership at various organizational levels (senior- and mid-level management).	Involve executive board (IEB), mandate change (MC) Framing to shift perspective (FSP)	(IEB/MC) Involve M in implementation process by T, review data (implementation process) (FSP) Appropriate to culture	Email with an invitation by T to M for an information session project as a result of problem analysis in 2020 and recent incidents with the message that the organization wants to and must improve behavior sustainably at all levels and specifically at the leadership level in view of the exemplary function. T sends an email with an invitation to the questionnaire and the workshop. M and W complete the questionnaire in preparation for the workshop. M and T discuss the questionnaire results and implications for the intervention project.
Adoption	Shared Vision M formulates a clear vision with regard to the change initiative with clarity about and confidence in the goals; this vision is inspiring and motivating, so that M and W are stimulated, and change is initiated	Persuasive communication	Rational arguments, relevant messages in line with the (true) conviction of the leader (i.e., M), repetition	M draws up an inspiring vision on safety. M carries out a new vision of the workplace supported by a concrete plan.
Adoption	Outcome expectation M has a positive expectation that evidence-based leadership training will help them to become (even) better leaders	Environmental reevaluation	Increase awareness that M acts as a role model for W	T makes M aware of the fact that they serve as a role model for W, and that the absence of safety leadership affects the safety behavior of W.
Adoption	Institutional commitment S supervises and promotes intervention project	Coordination, agenda setting	Requires proper timing and cooperation gatekeepers (M) and persuasive communication and awareness (S)	S acts as coordinator and promoter of the intervention project (i.e., the leadership training).

Table A2. *Cont.*

Phase	Determinant/Change Objective	Theoretical Change Method	Parameters	Practical Applications (Tools, Materials)
Maintenance (securing behavior change, preventing relapse)	Self-efficacy, skills, goal conflicts M jointly monitors the progress and results of the action plans and discusses and addresses any barriers (social pressure, goal conflicts)	Resistance to social pressure (RSP) Mobilizing social support (MSS) Planning coping response (PCR) Enhancing network linkages (ENL)	(RSP) Commitment to stated intention, relating intended behavior to (personal) values, psychological reinforcement against social pressure (MSS) Availability of a social network and potential support providers, information about the approval of the other, facilitation and persuasive communication (PCR) Identification of high-risk (difficult) situations and practicing the coping response (EN) Available network	M periodically gives feedback and support on progress in realizing action and coping plans during regular meetings. M jointly identifies (potential) barriers and ways to address them. T gives M additional coaching on leadership skills if desired. S is deployed or involved in any implementation problems. S and M may adjust implementation strategies to address barriers or deploy T for support if necessary.
Institutionalizing	Habitual behavior Breaking old habitual behavior, preventing relapse in the medium to long term, anticipating undermining goals	Audit and provide feedback, promote reinforcement	Regular monitoring and feedback	Action lists resulting from the training are entered by S into the PDCA cycle of the safety management system, and the results of M's improvement actions (individual and group levels) are periodically monitored, analyzed, and discussed.

Note. W indicates track workers; M, managers; T, trainers; S, safety manager.

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