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by van der Molen HF, Sluiter JK, Hulshof CTJ, Vink P, van Duivenbooden C, Frings-Dresen MHW

Affiliation: Academic Medical Center, Universiteit van Amsterdam, Coronel Institute for Occupational and Environmental Health, Research Institute AmCOGG, Meibergdreef 9, 1105 AZ Amsterdam, The Netherlands. h.f.vandermolen@amc.uva.nl

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Conceptual framework for the implementation of interventions in the construction industry

by Henk F van der Molen, PhD,[1,2] Judith K Sluiter, PhD,[1] Carel TJ Hulshof, PhD,[1] Peter Vink, PhD,[3] Cor van Duivenbooden, MD,[2] Monique HW Frings-Dresen, PhD[1]

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Objectives The objective of this study was to explore the necessary steps to define the implementation of interventions aimed at reducing physical work demands due to manual materials handling in the construction industry.

Methods A theoretical structured framework of six steps is outlined as a method for developing the implementation of interventions. In this framework, both the proposal for implementing the intervention measures and the context analysis are conditional.

Results Application of the framework in the development of the implementation of interventions to reduce the physical work demands for bricklayers and bricklayers' assistants has been presented.

Conclusions The framework was found appropriate for defining implementation strategies and (ergonomic) measures in the construction industry.

Key terms construction industry; implementation; intervention; manual materials handling; methods.

In the construction industry, the manual handling of materials (lifting, carrying, pushing and pulling) is a frequently occurring worktask (1–3). Reviews have shown the relationship between manual materials handling and the prevalence of musculoskeletal complaints (4, 5). Therefore, interventions have been planned to reduce both physical work demands and musculoskeletal complaints, in the longer run, for nine high-risk professions in the Dutch construction industry.

In implementation research, a systematic approach to the implementation of research evidence in daily work practices is recommended (6–9). It has been stated, for example, that, before intervention measures are implemented, different phases of accumulating research evidence with respect to the interventions to be used should be followed (6). Grol (7) suggests a framework for the implementation of research evidence that would lead to an understanding of barriers and opportunities involved in the implementation of guidelines in health care. In our report we have modified this framework into the following six steps (figure 1): (i) selection of the intervention measures, (ii) an analysis of the social and organizational context, (iii) goal setting (specification of the targets), (iv) selection of the intervention strategies, (v) development of an implementation plan for the intervention measures and (vi) implementation of the intervention measures and evaluation of the progress.

Before defining and evaluating implementation studies, it is recommended that a distinction be made between the (ergonomic) measures themselves and the strategies used to implement the measures (10). Our main objective was to explore [in line with Grol (7, 8)] a conceptual framework that would be usable in defining the intervention measures and, ultimately, implementation strategies aimed at reducing physical work demands due to manual materials handling for professions in the construction industry. The second objective was to apply this framework to the profession of bricklayers.

1 Academic Medical Center, University of Amsterdam (Department: Coronel Institute for Occupational and Environmental Health, Research Institute AmCOGG), Amsterdam, The Netherlands.
2 Arbouw, Amsterdam, The Netherlands.
3 Technical University Delft/Industrial Design, Delft, The Netherlands.

Reprint requests to: Dr HF van der Molen, Academic Medical Center, Universiteit van Amsterdam, Coronel Institute for Occupational and Environmental Health, Research Institute AmCOGG, Meibergdreef 9, 1105 AZ Amsterdam, The Netherlands. [E-mail: h.f.vandermolen@amc.uva.nl]

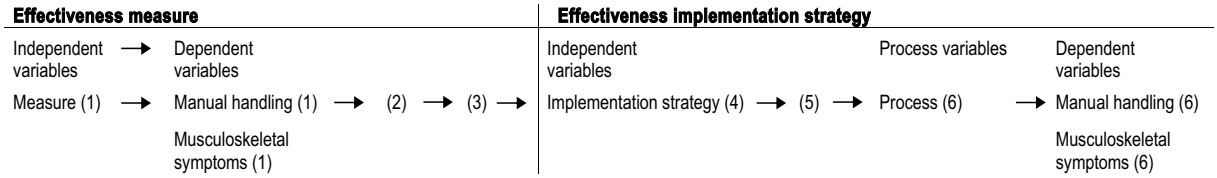

Figure 1. Scheme for the development and evaluation of interventions aimed at reducing physical work demands related to manual handling, musculoskeletal symptoms, and process variables, categorized according to the effectiveness of the measures and the effectiveness of the implementation strategies [van der Molen et al (10)]. The numbers in the figure refer to the steps from the framework for defining the implementation of intervention measures [modified from Grol (7)]: (1) selection of intervention measures, (2) analysis of social & organizational context, (3) goalsetting—specification of targets, (4) selection of intervention strategies, (5) implementation plan, (6) implementation & evaluation.

Conceptual framework

Selection of (ergonomic) intervention measures

The goal of step 1 is to select or develop a specific proposal for the intervention measures to achieve a (mostly) generally formulated objective. Effective measures that reduce physical work demands due to manual materials handling are the starting point of developing the implementation of interventions. The evidence for effectiveness can be obtained in two ways (11): (i) from scientific research evidence and (ii) from a consensus development (a systematic combination of evidence-based measures, practical experiences and consensuses between the involved employers and employees).

According to Campbell et al (6), reviews may lead to the improved specification of the active ingredients of an intervention. In addition, previous studies may have found evidence for closely related interventions. An analysis of surveillance data on diseases, injuries, risk factors, or exposures can be used as a guide for developing intervention measures (12). A special point of interest is the definition of research evidence for (ergonomic) intervention research. There are several concepts of evidence in intervention research, mostly separated into efficacy and effectiveness. Efficacy studies are conducted under optimized and experimental circumstances. These studies are often conducted in laboratory settings and, therefore, are not uniform enough to translate into real work settings (13). Effectiveness studies, like ergonomic intervention studies, are, by definition, conducted in a field setting and have to deal with problems of selection bias and confounding.

By means of participatory action research (empowerment methods), for example, stakeholders' perspectives can be taken into account in the selection of intervention measures. Explicitly, attention should be paid to the roles of all of the participants. Therefore, the participants in the intervention can actually already be involved in this first step.

In conclusion, the intervention measures of implementation studies should be based on a consensus of involved experts and actors with respect to the assumed effectiveness of these measures and, preferably, evidence-based in nature.

Analysis of the social and organizational context

The goal of step 2 is to detect obstacles or stimuli with respect to all of the actor groups involved in the implementation of the intervention measures. Different authors stipulate the importance of analyzing the social and organizational context of interventions (12, 14–16). The ultimate goal in most intervention studies at work is to actually change the behavior of the workers, supervisors, and employers involved. Therefore, the knowledge, attitudes, and behavior of the target populations are critical when the introduction of effective intervention measures is the aim (12). Obstacles that hinder the implementation of measures within the intervention population must be analyzed before the implementation plan is established (8, 12, 17). This analysis can be performed in different ways (eg, through pilot studies, literature research, interviews, questionnaires, or expert opinions).

To detect possible obstacles to the implementation, all of the actor groups should be taken into account in the analysis of the social and organizational context. For the implementation of measures, the following four groups can be defined (18, 19): users, importers, decision makers, and facilitators of the intervention measures under study. Users, as "participants" in the intervention, actually work with the proposed measures. Importers are people that facilitate the implementation of the measures in daily work, either directly or indirectly. Decision makers advise or decide about whether the implementation of the measures in the work situation will take place. Finally, facilitators are defined as actors outside the companies that can stimulate the implementation of ergonomic measures within the companies (ie, labor inspectorates, research institutes, or trade unions). During the implementation of intervention measures, the users may be the primary target population, but, if obstacles are to be eliminated or processes stimulated, the other actors are also important.

In implementation studies, the following seven levels of changing behavior with respect to intervention measures can be distinguished for every actor [modified from Grol & Wensing (9) and NIGZ (19)]: (i) being aware of the intervention (accessible), (ii) understanding the intervention, (iii) wanting the intervention (conscious), (iv) intending to buy (lease) the intervention,

(v) able to use the intervention, (vi) using the intervention (experience), and (vii) continuing to use the intervention. On every level, an obstacle can arise that would cause an actor not to proceed in the change process.

In conclusion, both goal setting and the selection of implementation strategies should be based on the results of this context analysis.

Goal setting

Step 3 is aimed at specifying the targets of the implementation of intervention measures (goal setting). The goals should be chosen according to the acronym SMART (specific, measurable, achievable, realistic and timed). "Specific" means that the targets should reflect the planned results of the intervention. For example, when the intervention is aimed at decreasing musculoskeletal symptoms by adjusting lifting heights, the result should reflect improved trunk and shoulder postures instead of changes in external force exertion (20). "Measurable" assumes that valid and reliable methods are used to assess the outcome measures according to an adequate measurement strategy (21–23). Changes in work practices can be used as proxies for decreased exposures (12, 24). Kilbom (25) defines such proxies as intermediate outcome measures. "Achievable" reflects the dependency on resources such as money, people, project organization, and a commitment to the planned intervention measures (12). "Realistic" refers to the need for realistic planning to achieve the targets since implementation is considered to be time consuming. Therefore, focusing the implementation on the expected early adopters of new work methods (18, 26) is more realistic than focusing on the group that obstructs changes. Incorporating (ergonomic) measures in daily activities and existing work structures of the intervention populations facilitates the implementation (24, 27). "Time" must correspond with the goals of the intervention. An intervention aimed at reducing musculoskeletal complaints, for example, needs a longer period of time than interventions aimed at reducing the physical work demands only.

Step 3 should result in concrete and measurable goals for the implementation phase.

Selection of intervention strategies (implementation strategies)

The goal of step 4 is to select the strategies that tackle the obstacles to (or, formulated in a more positive way, that facilitate) the implementation of the measures. Measures, defined as ergonomic controls to eliminate or reduce physical work demands, can be the proposed intervention measures. Implementation strategies are defined as the planning and process of the implementation of (assumed) effective measures aimed at incorporating them into the job, the work organization, and the sector of industry (28).

At least the following five different strategies can be distinguished (11, 19) and matched with the found obstacles to, and facilitators of, the implementation of intervention measures: informational, compulsory, educational, persuasive, or facilitating strategies. For example, if an actor is "not aware" of a health risk, an informational strategy can be used to explain the cause and consequences of the risks. "To understand" the intervention measure, more emphasis on tailored information or personal contact can be chosen. "Wanting" the intervention measure can be facilitated by trials and positive arguments (healthier, more efficient, cheaper). The "intention to buy (lease)" an intervention measure can be facilitated by financial support (tax advantage, lease construction). Education and instruction are examples of strategies that help a worker "be able to work" with the intervention measures. Experience with the measure during daily work is thought to be an essential element in the change process (27, 29).

"Performance" indicators (or outcomes of the process) should be selected for every step, to give the possibility of a valid measurement of the stage of the change process with respect to the actors involved. Indicators can be selected for structure, process, or outcome aspects, depending on the element of interest. These indicators should be made operational by means of criteria (30). Furthermore, process data are usually more sensitive and more informative measures of the quality of the implementation when compared with outcome data (30, 31) and less susceptible to confounding.

In conclusion, step 4 should result in the selection (of a combination) of strategies and performance indicators to facilitate and measure the process of the implementation of the intervention measures.

Development of the implementation plan for intervention measures

Step 5 involves developing an implementation plan for the intervention. This plan is a combination of the (assumed) effective measures to reduce the physical work demands (results of step 1) and the planning of optimal strategies for the group of actors to implement these measures (results of steps 2, 3, and 4). The effectiveness of the intervention measures according to scientific studies is a prerequisite for starting and executing the implementation of intervention measures. Before the assumption of effective measures is valid and can be made, a (pilot) study to determine the effectiveness of the proposed intervention measures should be planned.

Step 5 should result in an implementation plan with a defined time and financial perspective. This plan is a combination of the intervention measures and the intervention strategies for different groups of actors.

Implementation of the intervention measures and the evaluation of progress

The ultimate goal of step 6 is to demonstrate the impact of interventions. A control group that is comparable to the intervention group with respect to individual and job exposure variables should be planned as a prerequisite (22). A true experimental design (a-select, randomized controlled) is scientifically the most rigorous design, but it is difficult to achieve in a field setting (32) because of the scarcity of experienced possibilities for randomization in companies. A quasi-experimental study design is thought to be an alternative with which to assess the implementation of intervention measures on manual materials handling. The principal goal in choosing this design should be the ability to show that the intervention will make a difference (internal validity) and that the results are generalizable (ie, external validity), while the resource (eg, time, funding, expertise) and feasibility (eg, political and practical limitations, needs of partners) limitations are also addressed (12).

In step 6, the total intervention (measures and implementation strategies) should be executed and evaluated. The selection of an adequate study design and the selection of both effect and process variables can be the most important elements in evaluations of an implementation study.

Framework applied in the implementation of interventions for bricklayers

In The Netherlands, within a time frame of 3 years, implementation interventions were planned that were aimed at reducing the physical work demands and the musculoskeletal complaints, in the longer run, for nine professions in the Dutch construction industry. Bricklayers (21 700 bricklayers and an estimated 8 000 assistants, together comprising 15% of a whole worksite population) formed one of the target groups for the implementation of interventions. The facts that are presented in this report came from research studies, expert opinions, questionnaires, and interviews of employers and employees.

Selection of intervention measures to reduce physical work demands

The selected intervention measures for bricklayers in The Netherlands, the mechanization of transport and the optimization of work heights, were based on research evidence (20, 33, 34) and on a consensus document between the employers and employee organizations in construction (35). Case studies (36, 37), reviews (10, 22, 38), and an exploratory trial (20) were used as elements for the ultimate selection of the ergonomic measures. It was established that bricklayers and bricklayers' assistants work as a team. Normally, one assistant works for two to five bricklayers. The tasks between the two professions overlap. The task with the highest physical work demands is the manual transport of bricks and mortar (manual lifting and carrying materials and pushing–pulling wheelbarrows during more than 4 hours every workday) for the assistant and one-handed repetitive lifting of bricks (1 to 6 kilograms in awkward postures of the lower back during more than 4 hours per day) for the bricklayers. As an ergonomic measure, the mechanization of transport (figure 2) was selected as an intervention measure because it eliminates most of the lifting and carrying of materials. For the mechanization of bricklaying, there are no feasible solutions. Reducing awkward work postures with several devices to optimize lifting height (figure 3) was selected as an ergonomic measure.

Figure 2. Mobile crane for transporting bricks.

Figure 3. Trestles for adjusting the storage height of bricks and mortar.

The effect of work height and the mechanization of transport of materials on physical work demands and local discomfort were evaluated during a within-participants, controlled field experiment for bricklayers' work (39).

Analysis of the social and organizational context of bricklayers and goal setting

From all of the different actor groups involved in the implementation of the selected ergonomic measures, a division was made into the following four groups: *users* (bricklayers' assistants, bricklayers, crane drivers, equipment services), *importers* (employers or management, foremen, purchasers, general contractors, scaffolders), *decision makers* (work planners and calculators, employers or management, manufacturers and suppliers, architects, principals) and *facilitators* (eg, government representatives or the labor inspectorate, parties involved in the collective labor agreement, occupational health and safety services). Table 1 shows the estimated motives and arguments of all of the involved actors in each group for implementing one of the supposed implementation intervention measures (ie, the mechanization of transporting bricks and mortar).

Table 1. Estimated motives and arguments of the involved actor groups for the intervention measure "mechanization of transport". (+ = positive, – = negative)

Actor group	Motives	Arguments
Users		
Bricklayers' assistants	+	Easier work, healthier, better image
Bricklayers	+	Time saving, healthier
Crane drivers	+	Part of job
Equipment services	+	Pride on logistics
	–	More work for maintenance and logistics
Importers		
Employers	+	Efficient, less damage, healthier, cheaper
Foremen	+	Efficient, less damage, healthier
Purchasers	+	Cheaper
General contractors	+	Efficient to arrange logistics for all subcontractors, cheaper
	–	More attuning
Scaffolders	+	Quality of work increases
	–	Depends on general contractor
Decision makers		
Work planners	+	Quality
	–	More work for maintenance and logistics
Employers	+	Healthier work, legislation
	–	Unknown cost-benefit, no tailored information, no trial, no financial aid
Manufacturers, bricks	+	Consolidation of market, better image
Architects, principals	+	Legislation
	–	Not primary concern
Facilitators		
Organizations, employers	+	Commitment by national agreement
Unions	+	Commitment by national agreement
Labor inspectorate	+	Commitment by national agreement, legislation
Suppliers, cranes	+	Chances for new market
Occupational health services	+	Collective contract for construction workers facilitates knowledge transfer
Educational institutes	+	Eager to offer training in new work methods
Research institutes	+	Scientific involvement, mission to improve work conditions

The assessment of the motives of each actor group in relation to the selected ergonomic measure was based on the expert judgment of three experienced ergonomists in construction. Arguments were available to support the implementation of mechanized transport for bricks and mortar for all of the actor groups. Nevertheless, for 6 out of the 20 actor groups, there were also obstacles. Three actor groups were directly involved inside the companies and three outside. For the equipment services and work planners, a negative side effect could be the extra time needed for maintenance and the management of the installation of the new equipment. For the employer, the unknown cost-benefit of mechanization could be a reason for not implementing this measure. The general contractor is the most important actor outside the company that can hinder the implementation of mechanized transport. This actor has to make appointments with the scaffolders and other subcontractors about the capacity, layout, and costs of the scaffold.

By means of a questionnaire, employees (N=739) were asked about the degree of and barriers to the implementation of ergonomic measures. The selected ergonomic measures, mechanized transport and optimized work height, were included in this questionnaire. Most of the bricklayers and bricklayers' assistants knew of the selected ergonomic measures, but the degree of actual use of these measures differed considerably. The employers subscribed to the health risk of manual materials handling but stated that they had made progress already in reducing its physical work demands. Five interviewed employers knew of the selected ergonomic measures and acknowledged that they could reduce the physical work demands associated with manual materials handling. They believed that bricklayers and bricklayers' assistants would accept the measures when implementation became a fact. But the willingness to invest in measures was less univocal. Reported obstacles to implementing the lifting devices are the insufficient amount of structured information available about lifting devices and the necessity for such implementation; the unknown (financial) advantages and disadvantages associated with the implementation of the devices; no possibility to test the devices on a smaller scale; no financial aid or leasing available. The favorite implementation strategies among the interviewed employers were personal communication, tailored information, demonstration projects, manufacturer's information, financial aids, and possibilities for trying the lifting devices. Because attitude alone is not enough to change the behavior in the targeted direction among involved actors, an assessment was made of the position of the most direct actors at the worksite with respect to their placement in

the behavioral change process for the two types of selected ergonomic measures (tables 2 and 3).

For the implementation intervention study, the intention of the organizations of employers, employees and the government to reduce musculoskeletal complaints was operationalized into three main goals. The first was a 10% increase in work with the selected ergonomic measures (ie, mechanized transport and optimized workheight) after 1 year, as the ultimate "performance indicator". Examples of other "performance indicators" are determination of the readiness to participate in the implementation process after 1 month, determination of the involvement of all of the stakeholders and actors after 1 month, and determination of new required skills of the bricklayers after 2 months. The second was a 10% decrease in physical work demands with respect to the frequency of lifting and carrying loads during the task of transporting materials, and with respect to less back flexion of more than 60 degrees during the task of bricklaying (by means of a 1-month experimental study or a questionnaire after 1 year). The third was a 10% decrease in musculoskeletal discomfort in the lower back and shoulders after work on the shorter term and a 10% decrease in the prevalence of musculoskeletal symptoms of the lower back and shoulders after at least 1 year.

Selection of the intervention strategies and implementation plan

A comparison of tables 2 and 3 shows that the intervention measure of mechanized transport is in a more advanced stage of the change process than the intervention with an optimized workheight. Because all of the actors are in different stages of this change process, a combination of all the following strategies was selected for the implementation of the intervention measures for bricklayers at the national level: (i) an informational strategy (dynamic database with various engineering controls on the internet, code of practice for bricklayers, manual to introduce the proposed equipment in the companies, national publicity campaign); (ii) compulsory strategy (tailored legislation on the proposed implementation intervention); (iii) educational strategy (from suppliers and manufacturers of engineering controls, vocational training); (iv) persuasive strategy (demonstration and participatory ergonomic projects to facilitate the implementation of ergonomic measures); and (v) a facilitatory strategy (financial and personal support, commitment of unions and employers organizations).

Implementation of the intervention measures and an evaluation of progress

A special project organization with a specified budget (50% by government and 50% by employer's organizations and unions) is available to reduce manual handling for nine professions, whereof the bricklayers are one. The intervention of the whole branch of bricklayers will be monitored by means of a fixed cohort, measuring perceived physical work demands, use of ergonomic measures, and the prevalence of musculoskeletal complaints, particularly from the low back and shoulders. At the company level, a randomized controlled trial on the effectiveness of a participatory ergonomic implementation strategy on the use of ergonomic measures is planned. Performance indicators have been defined to measure the quality and degree of the implementation process.

Discussion

To maximize compliance, a thorough description of the intervention and the intervention process is necessary. Identifying barriers or facilitators for the implementation is an important part of this process. In the applied six-step framework with respect to bricklayers, the proposed intervention measures and the implementation strategies are based on a context analysis of stakeholders (actors) and on a diagnosis of the physical work demands and the use of possible intervention measures at baseline. The context analysis was achieved by means

Table 2. Estimation of fulfilled phases (x) in the behavioral change process of mechanizing transport in six actor groups.

	Bricklayers' assistants	Bricklayers	Foremen	Work planners	General contractor	Employers
1. Aware of it	x	x	x	x	x	x
2. Understand it	x	x	x	x	x	x
3. Want it	x					
4. Intention to buy or lease it						
5. Ability to use it						
6. Use it						
7. Continue use it						

Table 3. Estimation of fulfilled phases (x) in the behavioral change process of work between knee and shoulder height in six actor groups.

	Bricklayers' assistants	Bricklayers	Foremen	Work planners	Scaffolders	Employers
1. Aware of it	x	x	x	x	x	(x)
2. Understand it	x	x				
3. Want it						
4. Intention to buy or lease it						
5. Ability to use it						
6. Use it						
7. Continue to use it						

of questionnaires for employees and interviews for employers and expert guesses for the other involved actors. Checking the results of this analysis through participatory meetings (eg, round table sessions) (40) is another option to consider.

The planned implementation strategies focus on a combination of informational, compulsory, educational, persuasive, and facilitating strategies. This approach is in accordance with the recommendations of Linton & Van Tulder (41), who stated that preventive studies should focus more on multidimensional programs that tailor the program to the risk profile of the worker or the workplace. In addition to a sufficient follow-up period and large study population, it is essential to put effort into increasing the compliance to preventive interventions. The concept of participatory ergonomics is often reported as a means with which to increase the implementation of interventions (14, 27, 42). Essential in the approach is that it is of a participatory nature (43). Stepwise strategies, like participatory ergonomic approaches, can also be used to monitor the implementation process. In a planned controlled study at the company level, a participatory approach will be used to increase compliance. Through follow-up measurements, this process will be monitored by means of "performance indicators". At the branch level, compliance will be more difficult to achieve. The same intervention measures will be applied, but no direct involvement with stakeholders is guaranteed (ie, by means of a participatory ergonomics process). Through a combination of implementation strategies, the compliance at the branch level will be stimulated and monitored.

Both physical work demands (external mechanical exposures) and health variables should be measured when intervention is directed towards manual materials handling to improve musculoskeletal health (22). Knibbe & Friele (24) have also emphasized the importance of assessing exposure to physical work demands in creating more understanding of the direction, effects, and side-effects of preventive interventions for manual handling. Such action has taken place in an experimental study after the specification of the engineering controls (ie, mechanized transport and bricklaying at an optimized workheight). In the intervention groups, as well as in the control groups, of bricklayers, physical work demands can be assessed through direct measurement and observations to quantify all three dimensions of the physical work demands involved. The measurement should be applied to whole teams of bricklayers and during a whole workday to detect shifts in physical work demands over the day. By means of a logbook, the frequency and duration of use of the ergonomic measures can be evaluated during the implementation phase through self-report. Knibbe & Friele (24) used a frequency-oriented log, because practical problems in nursing limit the use of continuous direct observation and measurements.

According to Westgaard & Winkel (22), the following four elements should be considered in the design of an intervention study aimed at reducing physical work demands and musculoskeletal complaints: the scientific quality, a thorough description of the intervention and intervention process, the sustainability of the intervention, and the inclusion of both exposure and health effect variables. In applying the framework for defining the implementation of the intervention measures in the construction industry, all these aspects are taken into consideration.

For the profession of bricklayers, the six steps of the framework resulted in the selection of the following two types of intervention measures (ie, mechanized transport and adjusted workheight) and in a combination of strategies to implement these measures. An implementation plan, containing 27 facilitating projects, has been appointed by unions and employers' organizations. The time that is needed to analyze the social and organizational context could be seen as a drawback on the short-term. On the longer-term, the chance of compliance and intervention sustainability may be increased by means of the structured approach that resulted both in intervention measures and in intervention strategies.

In conclusion, the proposed six-step conceptual framework for defining the implementation of interventions aimed at reducing physical work demands due to manual materials handling has been found practical and applicable in a study of bricklayers. The framework is probably also applicable and useful for other professions in the construction industry.

References

1. Spielholz P, Wiker SF, Silverstein BA. An ergonomic characterization of work in concrete form construction. Am Ind Hyg Assoc J 1998;59:629–35.
2. Heran-Le Roy O, Niedhammer I, Sandret N, Leclerc A. Manual materials handling and related occupational hazards: a national survey in France. Int J Ind Ergon 1999;24:365–77.
3. Hoozemans MJM, Van der Beek AJ, Frings-Dresen MHW, Van der Molen HF. Evaluation of methods to assess push/pull forces in a construction task. Appl Ergon 2001;32(5):509–16.
4. Frank JW, Kerr MS, Brooker AS, DeMaio SE, Maetzel A, Shannon HS, et al. Disability resulting from occupational low back pain, part I: what do we know about primary prevention? a review of the scientific evidence on prevention before disability begins. Spine 1996;21(24):2908–17.
5. Kuiper JI, Burdorf A, Verbeek JHAM, Frings-Dresen MHW, Van der Beek AJ, Viikari-Juntura ERA. Epidemiologic evidence on manual materials handling as a risk factor for back disorders: a systematic review. Int J Ind Ergon 1999;24:389–404.
6. Campbell M, Fitzpatrick R, Haines A, Kinmonth AL, Sandercock P, Spiegelhalter D, et al. Framework for design and

evaluation of complex interventions to improve health. BMJ 2000;321:694–6.
7. Grol R. Beliefs and evidence in changing clinical practice. BMJ 1997;315:418–21.
8. Grol R, Jones R. Twenty years of implementation research. Fam Pract 2000;17(S1):S32-S35.
9. Grol R, Wensing M, editors. Implementatie; effectieve verandering in de patiëntenzorg [Implementation; effective change in patient care]. Maarssen (The Netherlands): Elsevier; 2001.
10. Van der Molen HF, Sluiter J, Hulshof CTJ, Vink P, Frings-Dresen MHW. A systematic review of the effectiveness of measures and implementation strategies to reduce physical work demands due to manual handling at work. Scand J Work Environ Health 2005;31 suppl 2:75–87.
11. Hulscher M, Wensing M, Grol R. Effectieve implementatie: theorieën en strategieën [Effective implementation: theories and strategies]. Den Haag: ZON / WOK; 2000.
12. Goldenhar LM, La Montagne AD, Katz T, Heaney C, Landsbergis P. The intervention research process in occupational safety and health: an overview from the national occupational research agenda intervention effectiveness research team. J Occup Environ Med, 2001;43(7):616–22.
13. Engels JA, Van der Gulden JWJ, Senden ThF, Kolk JJ, Binkhorst RA. The effects of an ergonomic-educational course: postural load, perceived physical exertion, and biomechanical errors in nursing. Int Arch Occup Environ Health 1998;71:336–42.
14. Westlander G, Viitasara E, Johansson A, Shahnavaz H. Evaluation of an ergonomics intervention programme in VDT workplaces. Appl Ergon 1995;26(2):83–92.
15. Silverstein BA, Stetson DS, Keyserling WM, Fine LJ. Work-related musculoskeletal disorders: comparison of data sources for surveillance. Am J Ind Med 1997;31(5):600–8.
16. Rockefeller K, Silverstein B, Howard N. Getting to zero-lift in Washington State nursing homes. In: Proceedings of the IEA congress. San Diego (CA): Human Factors and Ergonomics Society (Santa Monica); 2000. p 430–3.
17. Westgaard RH, Winkel J. Ergonomic intervention studies for improved musculoskeletal health: a review of the literature and some implications for practitioners. In: Proceedings of the IEA congress. San Diego (CA): Human Factors and Ergonomics Society (Santa Monica); 2000. p 490–2.
18. Rogers E. Diffusion of innovations. New York (NY): The Free Press; 1995.
19. National Intistut voor Gezondheidsbevordering en Zicktepreventie (NIGZ). Introductie basisprincipes implementatie [Introduction basic principles of implementation]. Woerden (The Netherlands): NIGZ, 2001.
20. Bongers PM, Luijsterburg P, Van den Heuvel F, De Vroome E, Miedema MC, Douwes M. Evaluatie van nieuwe werkmethoden voor de metselploeg: opgehoogd metselen en mechanisch opperen [Evaluation of new working methods for a team of bricklayers: heightened bricklaying and mechanization of transport]. Hoofddorp: Nederlandse Organisatie voor toegepast-natuurkundig onderzoek (TNO); 2001. Publication R2016811/1070130.
21. Winkel J, Mathiassen SE. Assessment of physical work load in epidemiologic studies: concepts, issues and operational considerations. Ergonomics 1994;37(6):979–88.
22. Westgaard RH, Winkel J. Ergonomic intervention research for improved musculoskeletal health: a critical review. Int J Ind Ergon 1997;20:463–500.
23. Van der Beek AJ, Frings-Dresen MHW. Assessment of mechanical exposure in ergonomic epidemiology. Occup Environ Med 1998;55:291–9.
24. Knibbe JJ, Friele RD. The use of logs to assess exposure to manual handling of patients, illustrated in an intervention study in home care nursing. Int J Ind Ergon 1999;24(4):445–54.
25. Kilböm A. Intervention programmes for work-related neck and upper limb disorders: strategies and evaluation. Ergonomics 1988;31(5):735–47.
26. Prochaska JO, Velicer WF. The transtheoretical model of health behavior change. Am J Health Promot 1997;12(1):38–48.
27. Haines H, Wilson JR, Vink P, Koningsveld EAP. Validating a framework for participatory ergonomics (the PEF). Ergonomics 2002;45:309–27.
28. Zorg Onderzoek Nederland (ZON). Met het oog op toepassing: Beleidskader Implementatie 1997–1999, samenvatting [Policy Memorandum Implementation 1997–1999, summary]. Den Haag: ZON; 1998.
29. Vink P, Kompier MAJ. Improving office work: a participatory ergonomic experiment in a naturalistic setting. Ergonomics 1997;40(4):435–49.
30. Van der Weide WE, Verbeek JHAM, Van Dijk FJH, Hulshof CTJ. Development and evaluation of a quality assessment instrument for occupational physicians. Occup Environ Med 1998;55(6):375–82.
31. Brook RH, McGlynn EA, Cleary PD. Quality of health care, part 2: measuring quality of care [editorial]. N Engl J Med 1996;335:966–70.
32. Kilböm A. Editorial: prevention of work-related musculoskeletal disorders in the workplace. Int J Ind Ergon 1998;21(1):1–3.
33. Vink P, Koningsveld EAP. Bricklaying: a step by step approach to better work. Ergonomics 1990;33(3):349–52.
34. Vink P, Miedema M, Koningsveld EAP, Van der Molen HF. Physical effects of new devices for bricklayers. Int J Occup Saf Ergon 2002;8:71–82.
35. Arbouw. A-blad Metselen en lijmen [A-document: bricklaying]. Amsterdam: Arbouw; 2002.
36. Vink P, Urlings IJM, Van der Molen HF. A participatory ergonomics approach to redesign work of scaffolders. Saf Sci 1997;26(1/2):75–87.
37. Van der Molen HF, Bulthuis BM, Van Duivenbooden JC. A prevention strategy for reducing gypsum bricklayers' physical workload and increasing productivity. Int J Ind Ergon 1998;21:59–68.
38. Grant K, Habes D. Summary of studies on the effectiveness of ergonomic interventions. Appl Occup Environ Hyg 1995;10(6):523–30.
39. Van der Molen HF, Grouwstra R, Kuijer PPFM, Sluiter JK, Frings-Dresen MHW. Efficacy of adjusting working height and mechanising of transport on physical work demands and local discomfort in construction work. Ergonomics 2004;47(7):772–83.
40. Ramsauer F. Prevention concept in industry: improvement in occupational safety and health protection – an empirical study. J Occup Rehabil 2001;11(4):321–30.
41. Linton SJ, Van Tulder MW. Preventive interventions for back and neck pain problems: what is evidence? Spine 2001;7:778–87.
42. Vink P, Lourijsen E, Wortel E, Dul J. Experiences in participatory ergonomics: results of a roundtable session during the 11th IEA Congress, Paris, July 1991. Ergonomics 1992; 35(2):123–7.
43. The European Foundation for the Improvement of Living and Working Conditions. Communique July / August 1999: 2. Dublin: The European Foundation for the Improvement of Living and Working Conditions; 1992.