Process Evaluation of an Intervention Program to Reduce Occupational Quartz Exposure Among Dutch Construction Workers

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Objectives: Evaluate the process of an intervention in the construction industry to reduce quartz exposure. **Methods:** In a cluster randomized controlled trial, data on seven process aspects (ie, recruitment, reach, dose delivered, dose received, fidelity, satisfaction, and context) were quantitatively collected on manager and worker levels. **Results:** Dose delivered was 95% for the plenary sessions and 20% for the worksite visit. Although the protocol was mostly implemented as intended, dose received was lower than expected. Both managers and workers appreciated the intervention and recommended the intervention for future implementation. Workers attending all intervention sessions were most satisfied about the intervention. **Conclusions:** High rates for dose delivered and fidelity for the plenary sessions and relatively high satisfaction rates were achieved. Furthermore, continuous monitoring of contextual factors beforehand and alongside the implementation of interventions is recommended.

The risks for construction workers to develop silicosis, lung cancer, and chronic obstructive pulmonary disease as a result of occupational quartz (ie, silica) exposure are generally acknowledged.[1–6] Several jobs and tasks within the Dutch construction industry show quartz exposure levels well above the Dutch occupational exposure limit.[7–9] International studies show similar exposure levels for comparable activities.[10–14] Particularly because of the potential for high exposure levels and its serious health consequences, silica has recently been selected by the Dutch government as a high-risk agent in the construction industry.[15]

Despite the fact that construction workers often have access to technical control measures, such as tool-integrated local exhaust ventilation and tool-integrated water suppression,[16,17] quartz exposure levels in the construction industry remain remarkably high.[18] Even though these technical control measures have been demonstrated to be effective in laboratory settings or under controlled workplace conditions,[19] the efficacy of these measures under actual working conditions seems to be lower. This can be explained by the fact that organizational factors, such as practical training of employees to use control measures properly,[20] and behavioral factors, such as motivation to use control measures,[21] also contribute to actual and effective use at worksites.[22] Therefore, intervention studies integrating technical, organizational, and behavioral factors could be considered as effective when reducing occupational exposure.[23,24] Such a multidimensional worksite intervention program, called the "Relieved Working" study, was developed to reduce quartz exposure in the Dutch construction industry.[25]

To date, intervention studies mainly focused on evaluating the effect(s) of the intervention rather than systematically evaluating the process to assess whether and why the intervention was successfully implemented or not.[26] Nevertheless, systematic process evaluations alongside randomized controlled trials are recommended to provide insight in the underlying causes of (un)successfulness of implementation or because of an inadequate implementation.[27–29] To what extent and how specific intervention components (eg, plenary sessions, worksite visits, and session for managers) are being delivered and to which extent these components are received and used (differently) by workers and managers may provide insight how the implementation of the intervention might influence outcomes.[26,29–31] In addition, a process evaluation provides more detailed information about the content and degree of implementation by many stakeholders across different companies and worksites.[26,27,29] Therefore, the aim of this study was to evaluate the process of the "Relieved Working" study among Dutch construction workers.

METHODS

The process evaluation was performed alongside a cluster randomized controlled trial on the effectiveness of an intervention to reduce occupational quartz exposure among Dutch construction workers. Detailed information on the baseline situation and intervention design has been published elsewhere.[9,25] No medical ethic approval was required for this study. The study has been executed according to the Dutch Data Protection Law.

Study Population

The study participants consisted of construction workers and managers of eight companies, which were randomly allocated to the intervention group ($n = 4$) or the control group ($n = 4$). All construction workers and managers in the intervention group were included in this process evaluation.

Intervention Program

The 6-month lasting intervention program was developed using the Intervention Mapping approach.[32] On the basis of this, the following program objective was defined: establish an increase in the (proper) use of technical control measures in the construction industry by targeting both the workers' behavior and organizational factors to significantly reduce occupational quartz exposure. Behavioral determinants that influence whether construction workers use technical control measures in a correct manner were assessed at individual level (ie, awareness, knowledge, risk perception, and skills) and at organizational level (ie, social–cultural and economic). These determinants were translated into intervention sessions and intervention materials. By default, two plenary sessions at the companies were provided to both managers and construction workers. In these

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sessions, the principal researcher and the occupational physician or labor inspector (the first and second plenary sessions, respectively) gave an oral presentation and initiated several discussions with the target group to increase awareness, knowledge, risk perception, and skills (Table 1). In addition, a separate workshop was organized only for managers and the principal researcher visited worksites for a supplementary session for construction workers measured at baseline. Baseline measurements (ie, full-shift personal quartz exposure measurements, including detailed observations and a questionnaire on behavioral and organizational factors) involved a random sample of construction workers, because construction workers were measured on the basis of work supply (relevant tasks with exposure) and allocation of construction workers per worksite.[9] Accompanying intervention materials, for example, the documentary about potential health risks of occupational quartz exposure and the tailored factsheet, were introduced in one or more intervention sessions at the construction company (Table 1).[25]

Process Evaluation

Based on the framework of Steckler and Linnan,[33] seven process aspects were assessed in this study. Six aspects (ie, recruitment, reach, dose delivered, dose received, fidelity, and, satisfaction) measure the degree of implementation. The seventh aspect, context, maps the barriers and facilitators that affect implementation.[28,33] Except for recruitment and reach, all process aspects were collected for the intervention group at worker and management levels.

Recruitment and Reach

Recruitment was defined as the procedure used to approach construction companies to participate. Logs completed by the principal researcher were used to collect information on the process of recruitment.

Reach was defined as the number of construction workers who were eligible to participate in the intervention program, that is, all construction workers employed by the four companies in the intervention group at the start of recruitment. Company records were used to collect data on reach.

Dose Delivered and Dose Received

Dose delivered refers to the number of intervention components, that is, two plenary sessions for construction workers and managers, an individual worksite visit for construction workers, and a workshop for managers, that were actually delivered to the construction workers and managers. Data were collected using checklists and logs containing information about reasons for not delivering sessions or materials, completed by the principal researcher.

Dose received at worker level was expressed as the proportion of construction workers who participated in the sessions (eg, first and second plenary sessions, worksite visit) compared to the total number of construction workers who were eligible to participate in the intervention program (ie, reach). For managers, dose received was expressed as the number of managers participating in each intervention session as the proportion of the total number of managers in the intervention group. Data were collected using attendance registration forms signed by the construction workers and the managers, and registration forms completed by the principal researcher. Reasons for not attending one of the sessions were registered by the principal researcher.

TABLE 1. Descriptive Overview of the Intervention Components per Determinant for Each Intervention Session*

		Behavioral Determinants				Organizational Determinants	
Intervention Session	Intervention Component	Awareness	Risk Perception	Skills	Knowledge	Social–Cultural	Economic
Plenary session 1†	Documentary health consequences	x	x			x	
	PIMEX videos‡	x	x	x			
	Tailored factsheet§	x			x		
	Posters	x					
	Quiz baseline survey‖				x		
	Presentation occupational physician				x		
Workplace visit¶	Assignment photographs	x					
	Discussion work practices	x		x			
	PIMEX videos‡		x	x			
	Tailored advice control measures			x			
Plenary session 2†	Documentary health consequences	x	x				
	Discussion constraints/facilitators control measures‖			x		x	
	Presentation labor inspector				x		x
Workshop#	Tailored demonstration control measures			x		x	
	Discussion constraints/facilitators control measures			x		x	
	Presentation availability and innovations control measures				x		x

*Different intervention components and intervention materials can affect multiple determinants; they are complementary to each other.
†All construction workers eligible to participate in the intervention and managers were invited to attend the plenary sessions.
‡PIMEX videos: Picture Mix Exposure, a video exposure monitoring method for exposure of hazardous materials to measure the impact of good and poor workplace practices and conditions at the same time.
§The tailored factsheet provides specific instructions on how to reduce quartz exposure at the worksite.
‖Presentations by the principal researcher (E.vD.).
¶Construction workers measured at baseline were visited on site.
#Managers were invited to attend the workshop.

Fidelity

Fidelity described the extent to which the intervention program was delivered according to the protocol. The protocol contained information about the outline and organization of the intervention including all specific sessions and materials. Moreover, the protocol described specific activities to be delivered by all implementers. Fidelity was examined by logs from the principal researcher, who attended all intervention sessions.

Satisfaction

Satisfaction was defined as the participants' satisfaction toward the intervention program and its specific components. Managers and construction workers were asked to evaluate the intervention, and the specific sessions (ie, plenary sessions, worksite visit, and workshop) and materials (ie, factsheet, documentary, and PIMEX videos [ie, Picture Mix Exposure; video exposure monitoring method to visualize the impact of good and poor workplace practices]) by using a questionnaire after the intervention period. Construction workers who participated in an intervention session received the process questionnaire from either the principal researcher or the manager, whereas managers received the questionnaire by e-mail. Satisfaction was measured by using a 10-point scale (ranging from *very unsatisfied* to *very satisfied*). Moreover, construction workers and managers were asked whether they would recommend the intervention for future implementation. Reasons for (dis-)satisfaction and suggestions for future implementation of the intervention (open-ended questions) were asked from managers.

Context

Contextual factors refer to factors and characteristics that either directly or indirectly may affect intervention implementation or study outcomes.[28,33] Three classes of contextual factors, as proposed by Fleuren et al,[34] were selected during data collection, that is, individual, organizational, and sociopolitical characteristics. Age and job category were selected as individual characteristics, based on the variety in exposure levels and use of control measures within the characteristics of the baseline survey,[9] and the impressions from the principal researcher that these subgroups' attitude differed during the intervention sessions. The extent to which a construction company already provided training programs in dust-reducing work practices before the baseline measurement was defined as organizational contextual factor. A cointervention at sociopolitical level, that is, inspection visits focused on quartz exposure by the labor inspection, occurred simultaneously alongside implementation. Because a previous study indicated that satisfaction was associated with compliance,[35] attendance rate was selected as a contextual factor specifically for satisfaction.

Data Analysis

Descriptive statistics (eg, percentage, mean, standard deviation) were generated for the seven process aspects. Differences in the scores for satisfaction between the categories of each contextual factor were tested using Mann–Whitney U tests and Kruskal–Wallis tests. Pearson chi-square tests or Fisher exact tests were performed to explore differences in the proportion of construction workers recommending the intervention and the proportion of construction workers attending the intervention sessions for each contextual factor. All statistical analyses were performed using SAS v9.3 (SAS Institute Inc, Cary, NC). Statistical significance was set at $P < 0.05$.

RESULTS

Recruitment and Reach

Through sectorial organizations for concrete drillers, demolishers and facade maintainers (ie, tuck pointers and bricklayers), a selection of companies ($n = 13$) were approached to participate in the intervention. Five companies were excluded because they employed too few permanent employees or because they had insufficient work supply during the period of the baseline survey. Subsequently, the principal researcher visited the remaining companies ($n = 8$; 62% of the invited companies) to provide information about the aims, content, and design of the intervention, whereupon they all committed themselves to participate in the study. These eight companies were randomly assigned to an intervention ($n = 4$) or control group ($n = 4$). Within the four companies comprising the intervention group, 227 construction workers were eligible for this study (ie, reach).

Dose Delivered and Dose Received

The first plenary session was delivered to all four companies (100%; dose delivered). This session was followed by 28% ($N = 63$; dose received) of all construction workers (ie, reach) (Table 2). The second plenary session was delivered to all four companies as well, attended by 54% of the construction workers ($N = 123$). Main reasons for not attending the plenary sessions were unemployment at the time of the plenary sessions or time constraints due to work demands.

The worksite visit involved 20% ($N = 45$) of all construction workers. Nevertheless, only construction workers from the intervention group measured at baseline comprising the random sample ($N = 47$) were eligible for a worksite visit. The worksite visit involved 55% ($N = 26$) of this subpopulation. Reasons for not receiving a worksite visit for those construction workers representing the random sample were practical infeasibility for the principal researcher ($N = 11$), unemployment ($N = 6$), or absence of the construction workers due to holidays ($N = 4$). Significant higher attendance rates were found in company II compared with the other companies. In total, 42% of all eligible construction workers followed none of the intervention sessions, whereas 58% followed at least one session and 11% followed all sessions (Table 2). All four managers attended the first and second plenary session at their company, as well as the workshop.

Fidelity

The first plenary session was delivered to all four companies as described in the protocol. According to the protocol, posters and factsheets were distributed within the company to reach all eligible construction workers, including those who did not attend the first intervention session. Based on the process questionnaire, 58% of these construction workers were aware of the poster and 54% of them received the tailored factsheet.

Accessible worksites were visited according to the protocol. The number of construction workers who received the advice at the worksite varied between one and five construction workers per worksite. Even though only the randomly selected sample of construction workers were planned to be visited by the principal researcher, additional colleagues at the worksite were also invited to participate in the worksite visit.

The second plenary session was not implemented as intended in all four companies as none of the construction workers fulfilled the assignment (ie, taking photos of good and poor work practices that were planned to be used for discussion in the second plenary session), because the assignment was considered as not worth time investment. Alternatively, the principal researcher showed photos, taken during baseline survey, in which technical control measures were used (in)adequately. By presenting these pictures, discussion about the good and poor work practices was initiated in all four companies. Subsequently, the session continued by addressing all other prescribed elements.

The workshop for managers was organized according to protocol. Available technical control measures were introduced via an interactive Web tool, where after managers had the opportunity to

TABLE 2. Proportion of Construction Workers (% (*N*)) Who Received the Intervention Sessions for All Construction Workers and by Company[a]

Reach (*N*)[b]	Total (*N*) 227	Company I (*N*) 81	Company II (*N*) 26	Company III (*N*) 54	Company IV (*N*) 66
Attendance per intervention session (%(*N*); dose received)[c]					
Plenary session 1	28% (63)	23% (19)*	92% (24)*	17% (9)*	15% (10)*
Worksite visit	20% (45)	25% (20)	31% (8)	15% (8)	14% (9)
Plenary session 2	54% (123)	77% (62)*	96% (25)*	37% (20)*	17% (11)*
Number of attended intervention sessions (%(*N*))					
None	42% (95)	17% (14)*	0% (0)*	55% (30)*	77% (51)*
1 session	28% (64)	52% (42)*	8% (2)*	30% (16)*	6% (4)*
2 sessions	19% (43)	20% (16)*	6% (17)*	6% (3)*	11% (7)*
3 sessions	11% (25)	11% (9)*	27% (7)*	9% (5)*	6% (4)*
Process questionnaires	41% (93)	46% (37)	88% (23)	35% (19)	21% (14)

*$P < 0.05$.
[a]N = number of subjects, in total or per company.
[b]At the start of inclusion (November 2011).
[c]All construction workers were invited for the plenary sessions, whereas only construction workers measured at baseline were eligible to receive a workplace visit.

practice with all technical control measures and to discuss possible constraints when using these measures.

Satisfaction

In total, 93 construction workers who participated in the intervention (ie, 70% of the construction workers who followed at least one intervention session) filled in the questionnaire. These construction workers were satisfied about the intervention (7.5) and its specific components (6.7 to 7.5; Table 3). Considering all scores more than 7 as satisfactory, construction workers were only moderately satisfied about the tailored factsheet (6.7). Not practical at the workplace was reported as main reason for not using the factsheet.

The majority of the construction workers who filled in the questionnaire (67%) recommended the intervention for future implementation. The main reason for recommendation was the insight into potential health risks of occupational quartz exposure. Of those construction workers who did not recommend the intervention, inevitability of occupational quartz exposure was their main reason.

Managers were moderately satisfied with the intervention and the second plenary session (6.5), whereas they were highly satisfied with the first plenary session (7.8), the documentary (7.5), and the tailored factsheet and PIMEX videos (7.3). All managers recommended the intervention for future implementation, as it serves as a first step to force all other stakeholders in the construction industry (eg, sectorial organizations, labor inspection, and contractors) to cooperate in addressing the risks of occupational quartz exposure. In line with this comment, the managers emphasized the need to receive information about changes in legislation and about innovations regarding technical control measures regularly.

Context

Job category as a contextual factor significantly influenced the satisfaction about the intervention sessions and materials (Table 3). More specifically, bricklayers were more positive about the intervention session and materials than other job categories; this difference in satisfaction was statistically significant for the tailored factsheet. Furthermore, construction workers who followed more intervention sessions (ie, at least two sessions) were significantly more often satisfied with the intervention sessions and materials than their colleagues. In addition, they more often recommended the intervention to colleagues for future implementation ($P < 0.05$) (Table 3). Slightly higher satisfaction rates for the intervention sessions were found among construction workers working within a company that offered training in dust-reducing practices before the baseline measurement, construction workers who received an inspection visit, and younger construction workers. Nevertheless, these differences were not significant.

The association between each contextual factor and the attendance rates is presented in Table 4. Construction workers working within a company who received an inspection visit attended significantly more intervention sessions. Also construction workers followed more intervention sessions when they were working within a company that did not provide training in dust-reducing practices before the baseline measurement. Nevertheless, this was not statistically significant. Job category influenced attendance rate, as concrete drillers, compared with other job categories, showed significantly lower attendance rates for the second plenary session.

DISCUSSION

Recruitment through sectorial organizations resulted in a reach of 227 eligible construction workers among four companies in the intervention group. Dose delivered was more than 95% for the plenary sessions, whereas it was only 20% for the worksite visits. Dose received of the managers for all sessions was 100%, whereas this dose was 58% for the construction workers. As construction workers and managers were satisfied about the intervention, the majority of the construction workers (67%) and all managers (100%) recommended the intervention for future implementation. Contextual factors, for example, working within a company that received an inspection visit or a company that did not provide training in dust-reducing practices before the baseline measurement, and job category (ie, bricklayers) were significantly associated with higher attendance rates. Satisfaction was significantly higher among bricklayers and among construction workers attending all intervention sessions.

Strengths and Weaknesses of the Process Evaluation

One of the main methodological strengths is the systematic data collection on all process aspects during all intervention sessions by using checklists, logs, and questionnaires. Because these data were collected among both construction workers and managers, their responses toward the questionnaire are helpful to modify the intervention and their suggested recommendations will, therefore,

TABLE 3. Satisfaction With the Intervention and Recommendation for Future Implementation Among Managers and Construction Workers in Total and for Each Contextual Factor

					Contextual Factor											
	Managers		Workers		Providing Training		Inspection Visit		Age Category		Job Category				Attending All Sessions	
Satisfaction (mean (SD))	$N = 4$	Total	$N = 93$[a]	Total	Yes ($N = 51$)	No ($N = 42$)	Yes ($N = 23$)	No ($N = 70$)	≤45 yrs ($N = 52$)	>45 yrs ($N = 37$)	Bricklayer ($n = 34$)	Concrete Driller ($N = 15$)	Demolisher ($N = 18$)	Tuck Pointer ($N = 23$)	Yes ($N = 25$)	No ($N = 68$)
Satisfaction with the intervention sessions																
Overall intervention	4	6.5 (1.7)	70	7.5 (1.6)	7.5 (1.8)	7.4 (1.5)	7.4 (1.4)	7.5 (1.8)	7.6 (1.7)	7.3 (1.6)	8.0 (1.6)	7.1 (1.2)	7.1 (2.0)	7.1 (1.9)	7.9 (2.0)	7.2 (1.4)
Plenary session 1	4	7.8 (0.5)	51	7.3 (1.5)	7.6 (1.3)	7.0 (1.6)	7.0 (1.4)	7.4 (1.5)	7.3 (1.4)	7.2 (1.7)	7.3 (1.4)	7.4 (1.4)	7.2 (2.3)	7.2 (1.3)	7.6 (1.6)	7.0 (1.3)
Workshop/visit[b]	4	7.0 (1.2)	44	7.2 (1.8)	7.3 (1.8)	6.9 (1.8)	6.9 (1.4)	7.3 (1.9)	7.7 (1.4)	6.5 (2.2)	7.4 (1.8)	7.1 (1.1)	7.1 (2.3)	7.1 (2.1)	7.8 (1.7)*	6.5 (1.6)*
Plenary session 2	4	6.5 (3.0)	86	7.0 (1.8)	6.9 (1.6)	6.5 (2.0)	6.8 (1.9)	6.7 (1.8)	6.6 (2.1)	7.0 (1.4)	7.3 (1.4)	7.3 (1.1)	6.0 (2.1)	6.1 (2.1)	7.7 (1.7)*	6.3 (1.7)*
Satisfaction with the intervention materials																
Tailored factsheet	3	7.3 (0.6)	50	6.7 (1.9)	6.7 (1.8)	6.7 (1.9)	6.6 (2.1)	6.8 (1.7)	6.5 (2.1)	7.0 (1.5)	7.5 (1.2)*	6.0 (1.1)*	7.4 (1.1)*	5.3 (2.5)*	7.1 (1.8)	6.4 (1.9)
Documentary	4	7.5 (0.6)	50	7.5 (1.6)	7.4 (1.8)	7.6 (1.4)	7.6 (1.6)	7.4 (1.6)	7.7 (1.8)	7.3 (1.2)	7.8 (1.5)	7.3 (1.1)	7.4 (0.9)	7.1 (2.3)	7.6 (1.8)	7.4 (1.4)
PIMEX	4	7.3 (1.0)	51	7.6 (1.4)	7.7 (1.6)	7.6 (1.3)	7.7 (1.5)	7.5 (1.5)	7.6 (1.6)	7.6 (1.1)	7.8 (1.5)	7.6 (1.0)	7.3 (0.8)	7.3 (2.1)	7.7 (1.8)	7.5 (1.1)
Recommendation for future implementation																
Overall intervention	4	100%	62	67%	69%	64%	83%	61%	71%	62%	65%	87%	39%	78%	96%*	56%*

*$P < 0.05$.
[a]Data were obtained from construction workers ($N = 93$) who completed a process questionnaire.
[b]The workshop was organized for managers, whereas construction workers received the worksite visit.

TABLE 4. Proportion of Construction Workers (% (*N*)) Who Attended the Intervention Sessions for Each Contextual Factor[a]

	Contextual Factor[b]									
	Providing Training		Inspection Visit		Age Category		Job Category			
	Yes (*N* = 93)	No (*N* = 55)	Yes (*N* = 26)	No (*N* = 122)	≤45 yrs (*N* = 77)	>45 yrs (*N* = 60)	Bricklayer (*N* = 52)	Concrete Driller (*N* = 28)	Demolisher (*N* = 26)	Tuck Pointer (*N* = 33)
Attendance per intervention sessions, % (*N*)										
Plenary session 1	31% (29)*	60% (33)*	92% (24)*	31% (38)*	45% (35)	38% (23)	50% (26)	43% (12)	27% (7)	39% (13)
Worksite visit	31% (29)	29% (16)	31% (8)	30% (37)	35% (27)	30% (18)	27% (14)	36% (10)	27% (7)	42% (14)
Plenary session 2	78% (73)	82% (45)	96% (25)*	76% (93)*	77% (59)	87% (52)	94% (49)*	39% (11)*	77% (20)*	97% (32)*
Number of attended intervention session, % (*N*)										
None	12% (11)	9% (5)	0% (0)*	13% (16)*	14% (11)	7% (4)	2% (1)	39% (11)	15% (4)	0% (0)
1 session	49% (46)	33% (18)	8% (2)*	51% (62)*	35% (27)	46% (28)	46% (24)	18% (5)	58% (15)	36% (12)
2 sessions	25% (23)	36% (20)	65% (17)*	21% (26)*	30% (23)	32% (19)	31% (16)	29% (8)	8% (2)	49% (16)
3 sessions	14% (13)	22% (12)	27% (7)*	15% (18)*	21% (16)	15% (9)	21% (11)	14% (4)	19% (5)	15% (5)

*$P < 0.05$.
[a]N = number of subjects.
[b]Data from contextual factors were obtained only from those construction workers ($N = 148$) who attended at least one intervention session, or who were measured at baseline or follow-up without attending at least one intervention session.

be feasible for future implementation. Feasibility is also facilitated because contextual factors are measured beforehand and continuously alongside implementation.[28,36,37] Hence, interventions are more likely to be successful if these factors are assessed.[28]

Some methodological limitations of this study must be considered as well. Although we considered the hierarchical structure of the study, that is, cluster randomization took place at company level and data from individual construction workers within these companies were used for analyses, the limited amount of observations was the major reason why we were unable to perform multilevel analyses. Because companies were recruited by sector organizations, the participating companies were probably early adopters[38] when it comes to health and safety. This recruitment procedure might have induced selection bias, so caution should be taken when generalizing the results to the entire sector.[39] Another potential source of selection bias might have been introduced by the random sample of worksite visits. Construction workers measured at baseline who were working on a worksite that was inaccessible were not able to attend all intervention sessions. Because attending all intervention sessions was associated with more positive satisfaction about the intervention, this source of selection bias may have affected satisfaction. Furthermore, absence of personal interviews with construction workers and managers limited interpretation of some of the process outcomes (eg, fidelity, satisfaction, and recommendation for future implementation). This information could have provided in-depth insights on facilitators and barriers alongside underlying reasons for implementation. The last limitation, which has been more often identified as general limitation of process evaluations,[28] was the absence of a defined definition and formula on the seven process aspects by Steckler and Linnan[33] to determine the success or failure of implementation. Therefore, no objective conclusion of the implementation grade of this study can easily be provided.

Interpretation of the Findings

Because no other process evaluations of interventions aimed at reducing dust exposure were published, our results were compared with process evaluations of two other studies[40,41] conducted in the construction industry that used a similar framework.

The commitment of companies to participate was higher compared to a previous study,[40] which could be explained by the close collaboration with sector organizations. In this study, these organizations personally invited a selection of companies. All construction workers employed within these companies were defined as reach. Because of ambiguous descriptions of several process outcomes in Steckler and Linnan's framework,[28] reach was differently defined across several studies that made comparison difficult.

Dose delivered of the plenary sessions was comparable with previous studies that also found rates more than 90%.[40,41] Compared to these studies, dose delivered of worksite visits was lower because of the infeasibility to visit some worksites and because of the random selection of construction workers who were eligible for a worksite visit. In line with this, dose received was low. This means that 70% of the construction workers followed none or only one of the sessions, even though construction workers were personally invited,[39] the intervention was developed with construction workers,[25] and organized at the worksite[42,43] within working hours.[38,42,44,45] This lower than expected dose received might be explained because attendance of the plenary sessions was not always obligatory and because the required travel time from their worksite to the central office (ie, place where the plenary sessions were held) was quite long for some construction workers. Contrary to the construction workers, all managers followed all three sessions.

Compared to previous studies,[40,41] fidelity was high as only the assignment was not completed by the construction workers. The aim of this assignment was twofold: (1) increasing the awareness and recognition of good and bad work practices at worksites and (2) initiating a discussion during the last group session. This second aim was still achieved by showing alternative photos taken by the principal researcher. Showing these photos can be regarded as adaptability, which is an important facilitator for implementation compared to interventions that must be conducted "as is."[36]

Construction workers and managers who attended all sessions showed comparable or even slightly higher satisfaction rates as compared with previous studies.[40,41] Moreover, in this study, slightly more construction workers recommended the intervention for future implementation if they attended all sessions. Previous studies showed that active involvement of construction workers and managers during the development phase of the intervention probably enhanced these satisfaction rates.[25,32,46,47] Nevertheless, the second plenary session was less appreciated by construction workers and managers, because of repetition of several elements from the first plenary session and stereotyping the construction industry by the labor inspector. In

addition, higher attendance rates during the first plenary session among construction workers working within a company that did not provide training in dust-reducing practices before the baseline measurement indicates that initiatives addressing relatively unknown topics have enough support in the beginning.

As mentioned in previous studies,[28,44] contextual factors, among others, at social–political level, i.e., inspection visits, influenced implementation. For instance, the frequent and strict inspection visits by the Dutch labor inspection in some companies may explain the higher attendance rates of construction workers during the second plenary session.

Implications for Future Practice

For a successful large-scale implementation of the intervention program, when effective, some lessons learned should be considered.

First, intervention sessions should be organized within working hours and within the obligatory toolbox education system or as elementary component within an already-scheduled meeting at the central office in which multiple themes concerning the company's policy are addressed. This approach increased attendance rates in company II, whereas it was also considered to be effective in previous studies.[38,40,42–45]

Second, managers and construction workers recommended to increase awareness and risk perception by continuous repetition of the attention on potential health risks of quartz exposure and solutions to avoid exposure. Several stakeholders involved during the development of the intervention suggested active strategies (eg, workshop, active presentation, and worksite visits) and audiovisual intervention materials (ie, documentary about potential health risks, PIMEX videos) as most promising techniques to disseminate this message because of the limited literacy skills of construction workers. Similar techniques among identical populations were also recommended in previous studies.[43,46] Because the intervention in this study was implemented in only four companies, some intervention components, for example, the documentary and tailored factsheet, need a revision. The main messages from the occupational physician and labor inspector should be incorporated in the documentary, as oral presentations during large-scale implementation are practical infeasible. In addition, because reading the factsheet was mentioned as not practical at the workplace (ie, we observed at the worksites that the factsheet was not decisive enough to affect workers' behavior), its content could be transferred into an application for mobile devices. Construction workers lacked photography, most likely because the assignment was announced once-only and because the construction workers were insufficiently accompanied by the principal researcher to complete the assignment. Therefore, the assignment could be transferred into the mobile application as well. Translation to visual materials would be recommended because the majority of the construction workers have a lower education level and because of the relatively easy accessibility to mobile devices nowadays. Although increasing compliance to the assignment might be difficult through such an application, that is, construction workers mentioned the assignment as not worth time investment, the application may enable dynamic between the intervention components and opportunities for the exchange of updated information for managers and other stakeholders.

Third, researchers and implementers need to be aware of contextual factors that can be identified beforehand and spontaneously running alongside implementation.[38] Based on the factors defined beforehand, previous studies recommend different implementation strategies to optimize the success of the implementation.[36] For example, in this study, participation might be enhanced if workers in each job category were approached differently; as bricklayers do not use control measures that often, tailored worksite visits and discussions about constraints and/or facilitators when using control measures could be replaced by other group sessions at the worksite aimed at, for instance, increasing awareness about tasks with potential (high) quartz exposure. Contextual factors can also take place spontaneously, such as the labor inspection visits during this study. Monitoring these contextual factors is important as it helps the interpretation of the effectiveness. In addition, integrating these unexpected events in the intended intervention strategy should be considered for future implementation in practice.

CONCLUSIONS

This process evaluation showed that dose delivered and dose received were high for the plenary sessions but lower for the worksite visits. Overall, the intervention was almost completely implemented according to the protocol, and the intervention sessions and intervention materials were highly appreciated and recommended for future implementation by both managers (100%) and construction workers (67%). Contextual factors that positively influenced implementation were (i) working within a company that received an inspection visit, (ii) working within a company that did not provide training in dust-reducing practices, (iii) working as a bricklayer, and (iv) attending all intervention sessions. The main lessons learned from this process evaluation are that an intervention in the construction industry especially should comprise audiovisual intervention components, which are implemented at the worksite.

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