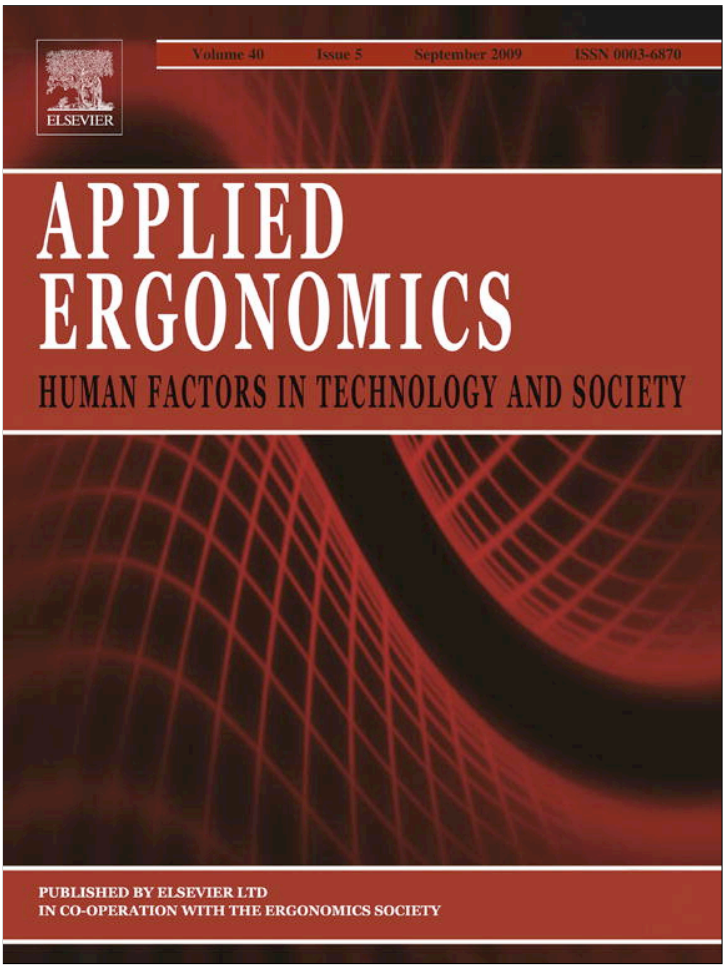

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Spreading good ideas: A case study of the adoption of an innovation in the construction sector

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ABSTRACT

A health and safety association collaborated with two research centres to examine the dissemination of knowledge of an ergonomic intervention by opinion leaders in the construction sector. The intervention was a hydraulic ladder lift that aided with loading and unloading of ladders off van roofs. Thirteen companies, with five to 900 employees, were involved. The van operators informed workmates not employed by their companies but who worked on the same site as them about the intervention. The opinion leaders informed decision makers within their companies which led to commitments to purchase similar units. They also gave presentations at prearranged health and safety meetings, where attendees indicated that they thought the intervention sounded like a good idea. In this way, knowledge of the innovation reached at least 32 more companies and potentially several thousand other employees. The study showed the potential for workplace change to be exponential.

1. Introduction

Construction workers are exposed to heavy manual material handling, repetitive movements, awkward postures, contact stress, vibration and forceful exertions. The physical demand is high and the control over product design and selection of materials is limited. The sector has one of the highest injury rates in Ontario, with musculoskeletal disorders (MSDs) representing 35% of all lost-time injuries in the rate group and over 30% of total direct WSIB costs.

Addressing health and safety issues and conducting research on health and safety in the construction sector is inherently more difficult than in a fixed industrial setting (De Jong and Vink, 2000; Schneider, 1995). The workplace is changing every day, the peripatetic workforce, and the complex project and organizational arrangements all mean that any health and safety intervention is difficult to implement or evaluate (Merlino et al., 2003; Moir et al., 2003; Van der Molen et al., 2005a). In addition, workers are constantly changing jobs, so the efficacy of interventions is difficult to gauge (Jensen and Friche, 2008; Schneider, 1995; Sorensen et al., 2006).

Despite these obvious issues, it has been shown that having safety initiatives in place does lead to better safety outcomes in this sector (Hoonakker et al., 2005), so ensuring that companies receive help with simple, inexpensive and efficient preventive measures (tools, processes, procedures) to reduce the risk of MSDs is essential in construction (Malchaire and Piette, 2002; Sexton et al., 2006). But how to communicate these measures is an issue. Practicing ergonomists and health and safety professionals find it difficult to communicate knowledge on MSD prevention (Mollo and Falzon, 2004) and even more so, to overcome the barriers to adopting new measures (Van der Molen et al., 2005b).

Acknowledging this as a problem, the Construction Safety Association of Ontario (CSAO), one of 14 sector-specific health and safety associations funded by Ontario's Workplace Safety and Insurance Board (WSIB), chose to collaborate with two research centres (the Centre for Research Expertise in the Prevention of Musculoskeletal Disorders and the Institute for Work & Health, that are also funded by the WSIB) to explore the potential for improving the introduction and adoption of ergonomic innovations in the construction sector, by using their expertise in knowledge transfer & exchange (KTE).

The two research centres use the concepts and techniques of KTE extensively with the goal of improving the effectiveness of transferring knowledge between communities (for example, ergonomists and workplaces; researchers and ergonomists) (Kramer and Wells, 2005). The model of KTE used by the two centres is based on a couple of theoretical foundations: the social interactionist model of knowledge transfer (Huberman, 1994; Lave

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and Wenger, 1988), and the diffusion of innovation theory (Rogers, 2003). The social interactionist model supports the idea that knowledge is essentially social and is created within a social context, and the more sustained and intense the interaction between researchers and potential "users" at multiple phases within the research study, the higher the potential for knowledge use. The concept of opinion leaders emerges out of diffusion of innovation theory (Rogers, 2003). Opinion leaders have multiple connections, are regarded as highly credible, and are influential in spreading new ideas.

How these conceptual frameworks are actualized as part of the research centres' activities, is that they invest in building strong relationships ("interactionist model") through regular contacts between their researchers and workplace decision-makers and involve these stakeholders throughout the research process (Thompson et al., 2006). Their stakeholders included potential users of research in the prevention of musculoskeletal disorders (MSDs) such as ergonomists, workplaces, organized labour, organizations and associations. This investment in relationship building has proven to be an effective KTE process (Kramer et al., 2004; Mitton et al., 2007) that in this research study led to the implementation of a change to reduce MSDs in construction.

Through this relationship-building, the CSAO collaborated with the research centres in initiating a more proactive dissemination of knowledge on the prevention of MSDs by using some of the principles of knowledge transfer and exchange, including using opinion leaders in the sector to promote new ideas, mining their existing network to hold discussions on MSD prevention, and creating focus groups with their member organizations to explore the major issues surrounding MSD prevention.

2. Background

2.1. Setting up a KTE case study

Using the networking ideas of KTE, the research group (made up of researchers from the two research centres and practitioners at CSAO), met with a number of trade-specific and labour-management health and safety sub-committees that CSAO operates at the provincial, regional, and trade/sector level. These committees are usually made up of 10 to 15 active members.

One of these groups, the Refrigeration/Air Conditioning committee identified a task they believed was a high risk for MSDs and falls, and identified an innovation that could potentially be very useful in reducing stress to the upper body and back. The task was taking ladders off and on the roofs of service vans. The innovation was a hydraulically operated, aluminium drop-down ladder rack.

The research process included: (1) holding a number of consultations with the CSAO sub-committees to identify companies that the sector believes are opinion leaders; (2) contacting the companies to gain their commitment to try out the ladder racks; (3) purchasing about 15 of the ladder lifts to distribute to the companies; (4) installing them on service vans; (5) giving the workers training on their use; (6) conducting interviews at staggered intervals with the workers to explore their perception of the benefits of the innovation; (7) conducting a biomechanical analysis of the innovation; (8) interviewing key people to profile the companies; (9) gaining the commitment from company representatives to talk at one of the CSAO committees about their experiences; and (10) evaluating the dissemination potential of this innovation.

2.2. Research questions

The research project was framed by the following research questions:

- Can opinion leaders help solicit construction workplaces to be involved in research?
- What are the barriers and facilitators to adopting ergonomic innovations in the construction sector?
- What are the characteristics of an innovation in construction that facilitates or retards its adoption in individual companies and its diffusion throughout the sector?
- What are the characteristics of "early adopter" companies in the construction sector?
- What are the challenges and facilitators in disseminating innovations in the construction sector?

3. Methods

3.1. Identifying the innovation

CSAO's Refrigerator and Air Conditioning Health and Safety Labour-Management Committee proposed that the repetitive lifting of ladders on and off vans puts maintenance workers at risk for injury and musculoskeletal disorders (MSDs) to the back and shoulders because of the weight of the ladder and the extended reach. There is also the risk of slips and falls because workers are stepping on and off the van bumper in order to remove the ladder from the roof.

The committee recommended a hydraulic aluminium drop-down ladder rack system, which allows workers to load or unload the ladder from the side of the vans. To raise or lower the ladder, the operator turns a control rod that allows a hydraulic cylinder to assist with raising or lowering the ladder rack (see Figs. 1 and 2 for pictures of the standard way of lifting a ladder, compared to the new hydraulic ladder lift).

Fig. 1. The old ladder lift.

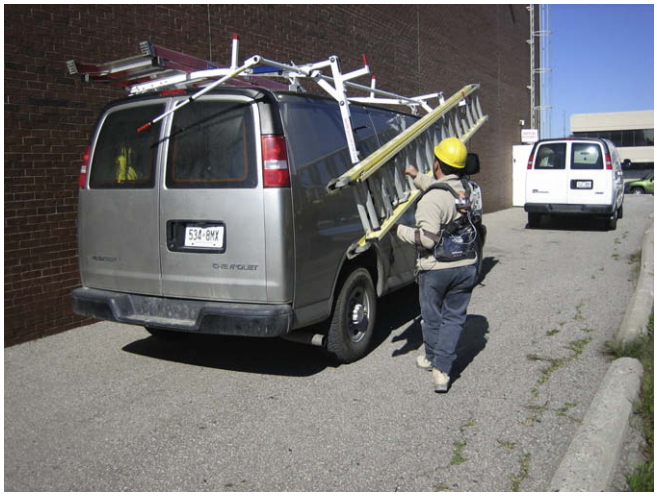

Fig. 2. The new ladder lift.

Supported by the research that has shown that ladder loading devices have been shown to lessen exposures to overhead lifting and likely lower injury risks (Gogue, 2007), the research team decided not to do a pre-biomechanical analysis, but to do one as part of the research process.

Since the committees had identified cost as a major barrier to adoption, the research team purchased the ladder lifts out of the research grant money. In this way, the team hoped that by offering the innovation for free, other barriers and facilitators to adoption would emerge. Thirteen new overhead ladder lifts for vans were purchased. They cost Can $1300 each, which includes installation by a local distributor. (This is in comparison with Can $900 for the purchase and installation of a standard fixed ladder rack).

3.2. Identifying opinion leaders in the construction sector

Soliciting the names of opinion leaders was done at two labour management meetings and four trade-specific committee meetings (electrical, pipe-trades, sprinkler and refrigerator), with the idea that leaders could be the springboard for innovation within the industry. They were asked: What company sets the trends in your sector? Who would you consider calling for help? Who is the "best" company in your sector? Which is the most "respected" company? Which company is the trend-setter? If an individual company was identified as an opinion leader more than three times, they were selected to be part of the study.

Initially 33 companies were contacted. Thirteen agreed to participate. Added to these were two companies who were already using the ladder lift, and three employers who did not accept the innovation, but gave information on their decision-making process.

3.3. Commitment from the opinion leaders

The companies committed to letting workers receive training while the ladder lift was installed; that workers would fill out questionnaires; and that the opinion leaders would participate in two semi-structured interviews. The companies would also give a talk on their experience with the ladder lift at a regional or trade-specific labour-management health and safety committee meeting. The expectation was that sharing their experiences, and perhaps endorsing the ladder lift, would help others decide to use it. This idea emerged from a study that found that a major barrier to the use of new ergonomic ideas in construction was the lack of a forum to share knowledge about interventions (Fulmer et al., 2006).

3.4. The intervention

A before-and-after design was used to evaluate the effectiveness of the hydraulic drop-down ladder rack in reducing worker effort. The design was chosen because it is the most useful in demonstrating the immediate impacts of short-term programs (Robson et al., 2001).

Thirteen workers brought their vans to have the hydraulic ladder racks installed at the distributor. While it was installed, a member of the research team (PV) trained the participant on the proper use of the ladder racks, including procedures to troubleshooting and ladder rack maintenance. Surveys were done with the workers at this time. The questions that were asked included: have you ever seen a hydraulic ladder lift like this before? Do you think the ladder lift will reduce the amount of effort you use to take down and put up your ladder? Is there any other equipment that you think the company should be purchasing to reduce your workload? If you like it, would you tell other workers about it?

After introducing the interventions, participants were encouraged to use the hydraulic ladder rack whenever it was appropriate. Each participant was allowed to use the hydraulic ladder rack continuously for 3 months, although the duration and frequency of use in the field were not evaluated.

3.5. Ladder rack usability follow-up questionnaires

The workers were interviewed three more times during the year over the phone regarding the usability of the hydraulic ladder rack. In all, 36 worker usability surveys were conducted. The self-report questionnaire used in this study was based on past studies conducted by Spielholz et al. (2001) and Punnett et al. (1991).

Workers were asked about past MSD injuries, perceived effort in performing ladder lifting, and perceived risk of accident or injury while handing ladders, including overall level of physical effort, shoulders effort, back effort, suitability of the rack design to reduce work load, how easy was the ladder rack to load/unload ladder, level of slip/fall hazard, and what level of struck-by or against-an-object hazard do they experience while loading and unloading ladders using the ladder rack system. These questions were answered using a 10-point Likert scale (from no effort to very high effort, or very, very easy to very, very difficult.

They were asked whether they found the ladder lift easier to use and performed well in all job conditions and weather, whether they had spoken to any other worker about using the ladder lift, whether they had told their supervisor that the ladder lift was working for you, and whether other employees had come to talk to them about the ladder lift. In the post-intervention questionnaire, the workers were also asked to rank the factors which they felt have an influence on their decisions to implement the innovation.

3.6. Ergonomic analyses

Four intensive ergonomic analyses of both the traditional way of taking ladders off vans and the hydraulic ladder lift were conducted. In this study, only the loading/unloading of the ladder rack task was used to evaluate the intervention. The workers were attached with an Xbus Master (Xsens Motion Technologies, The Netherlands, DATE) data acquisition devise and six MTx. The Xsens MTx is a self-contained sensor system that measures the three degrees of its orientation in space with respect to Earth's cardinal axes. The measurement outputs by the Xsens MTx provided work postures of the bilateral upper and lower arms, trunk and pelvis. The validity of the MTx to measure angle has been tested by Godwin et al. (2006). Once the MTx were attached to the participants, they were asked to perform simulated ladder lifting task from the top of the vans using a fixed ladder rack and a hydraulic drop down

ladder rack system. While performing the loading/unloading of ladders from the vans, video tape of the work task was also performed. The collected data from the MTx and the video tape information were used to calculate the two-dimensional peak L4/L5 compression force. Due to the small number of subjects, a statistical tests with $P < 0.1$ was considered significant.

3.7. Opinion leader surveys

Key informant interviews were conducted with 27 management representatives. The initial telephone interview with the opinion leaders lasted about an hour. It included questions on what influenced their decision to accept the ladder lift on a long-term basis, what made their company more innovative than others, and the changes they believed would be required, whether administrative, managerial, financial or organizational to facilitate further adoptions of innovations. Part of this interview schedule included questions adapted from Van der Molen et al. (2006) that tracks phases of adoption from awareness, through receptivity, understanding, and intention to buy, to the ability to use the innovation. There was a second, shorter, follow-up interview at the end of the project. Interviews were recorded, transcribed and analyzed for themes.

3.8. Opinion leaders share their experiences with peers

At the end of the pilot study, presentations were given on the ladder lift by the opinion leaders at four labour-management committee meetings and two sub-trade committees: pipe-trades and refrigeration; 32 people filled out evaluation questionnaires at the meetings on what they thought of the presentations.

3.9. Analysis

The effectiveness of the innovation and dissemination strategy was evaluated through an analysis of the worker usability surveys, the interviews of the opinion leaders, a biomechanical analysis of loading and unloading ladders using the hydraulic lift, and an analysis of the evaluation of the impact of the presentations of the opinion leaders by those attending the health and safety committee meetings.

4. Results

Our analysis identified four elements of the diffusion of innovation process that influenced the dynamics of adoption: (1) the relevance and usefulness of the innovation; (2) the characteristics of the adopting construction companies; (3) the credibility of the opinion leaders as promoters of the innovation; and (4) the barriers and facilitators facing the adoption of innovations in the construction sector. It also examined the effectiveness of the dissemination strategy.

4.1. The innovation

The findings from the biomechanical analysis indicated the ladder lift in comparison to a manual lifting off of a ladder reduced low back loading (Vi et al., 2007). A mean peak low back compression force of 3870 N (SD = 1120 N) was observed when participants lifted the ladder from the top of the fixed ladder rack. Using the hydraulic drop down ladder rack system, a mean peak low back compression force of 3540 N (SD = 1080 N) was observed. The peak forces occurred when participants lifted the ladder onto the side of the vans. A paired *t*-test was performed and a significantly ($P < 0.1$) higher peak low back compression force was found when participants used the fixed ladder racks. The results indicated a reduction in low back load when participants used the hydraulic ladder rack system.

From the pre-intervention worker surveys, we found that the ladder lift was a new innovation for more than 80% of the workers. Based on the 36 operator usability follow-up questionnaires, all the workers endorsed the lift as a significant improvement over the manual racks they were currently using. Generally, they found working with the ladder lift was easier, reduced their work load, and reduced the possibility of them slipping.

The list of what facilitated their adoption of new innovations, in no particular order, included: it will not deskill workers; it does not require having to learn something new or change the way work is done; it is too big to be stolen; it is affordable; it will improve productivity; it is accessible; it gets the job done quicker; it is a better tool that does the same thing; can be directly linked to a problem; affects enough workers doing the task often enough.

The workers believed that the ladder lift would reduce their musculoskeletal discomfort, and would reduce their fatigue at the end of the working day. They said that during loading and offloading, the load on their shoulders was reduced since their reach was now shorter, and their balance was improved since the ladders were held in the middle. They also thought it might reduce the potential of traumatic injuries from slips and falls as workers were no longer balancing on the van's back bumper to remove the ladder, especially during winter weather. This was especially true for the shorter workers. Yet another advantage was that the Velcro straps were easier to use and hence the ladder was more securely tied down.

However, the use of the ladder lift was limited since they were mostly used for larger extension ladders that were used only a few days a month. Despite this, the workers reported that they were frequently asked about the lift on worksites, and they were pleased to demonstrate it to their co-workers. They were asked for their opinion of its usefulness, and some had been asked by fellow-workers whether they could try it out. This enthusiastic verbal sharing of "know-how" has been found by another study to be a major medium of communication amongst construction workers (Styhre et al., 2006). One of the workers commented:

> I have a good friend in another company. It's a one-man company and I usually meet him once a week for lunch. He'd just bought a new rack for his van. He saw the ladder lift and asked, "Is that the one with the hydraulics?" and I said, "Yeah". He asked, "What do you think of it?" We stood there yapping and I showed him how [the hydraulic lift] worked and he said, "WOW!" He was sort of mad because he said he wished he hadn't bought his ladder rack and bought mine instead.

4.2. Characteristics of the adopting companies

The nature of the 13 companies who participated in the study varied considerably in size, nature of their business, status of employees, and union or non-unionized (see Table 1). They also differed by whether health and safety was driven by company-wide policies or not.

Table 1
Characteristics of the adopting companies.

Firm size	Large	Medium	Small	Total
Number of firms contacted	19	8	6	33
Number of firms participating	5	4	4	13
Number of manager interviews	10	9	8	27
Number of operator surveys	15	12	9	36
Average no. of workers/division	700	138	10	
Unionized/mixed work force	5	3	3	12
In house health and safety training	5	3	3	12

The 27 interviews with the management key representatives found that all of the companies endorsed the lift. It had many positive characteristics that facilitated its adoption. Yet a number of concerns were raised. A major concern was that none of the companies were able to identify any specific lost-time claims arising out of difficulties with lifting ladders off the roofs of service vans. As one manager said:

> I'd like to do additional follow up. … My sense of it would be that we would proceed on a priority basis for those whom the ergonomic risk was the most significant.

Surprisingly, considering that the literature often emphasizes that it is larger companies that adopt health and safety innovations (Ghobadian and Gallear, 1997) and it is the smaller companies that have the most difficulty in implementing changes (Van der Molen et al., 2005a), in our study, it was the smallest firms that most clearly indicated that they would be inclined to purchase the racks when they were replacing their current vehicles or racks, and that the additional cost would not be a significant factor. This could be because the decision-maker was also a worker who would benefit from the innovation, and also that the smallness of these companies may mean that the owner-operator could be more easily influenced by their workers. One commented that:

> You don't just look at accidents. You have to look at potential accidents. You assess the hazard. I am sure accidents could happen if guys have to pull the ladder off the top rack like they do now. I am sure there could be accidents. This type of ladder [lift] would reduce them.

4.3. Credibility of the messengers

The presentations that the 13 company management representatives gave to their peers at the sector-specific and management-union committee meetings were well received. Using the opinion leaders in the construction sector as messengers to promote the innovation seemed to be a good strategic choice although there were not enough of them to make a real difference. Those who heard the opinion leaders' presentations (about 30 of their peers) expressed that they appreciated hearing the personal experiences and opinions. They held in high regard this real-life field experience, and said that what really mattered to them was to hear from someone who had actually used the ladder lift. Additionally, because construction companies do share work sites, this was an opportunity for workers from other companies to see the ladder lift in use.

4.4. Barriers and facilitators to the adoption of innovations

The barriers to adopting innovations to reduce MSDs mentioned by the management representatives included a lack of awareness of the problem, a lack of confidence in their expertise, their inability to control their work environments, and costs.

Most stated that they did not believe that MSDs were an issue in construction. Since MSDs are either not on their radar, or are seen as a field outside of their expertise, it is not surprising that most of the companies had not heard of the ladder lift before being involved in the study. Many said that although they felt confident about managing safety issues and having systems and processes in place to manage safety, they feel unqualified to manage ergonomic problems.

When we asked about the decisions to purchase ergonomic equipment other than the ladder lift, many of these company representatives expressed their frustration with their limited ability to control or influence ergonomic improvements. These frustrations are similar to those that were expressed in a larger stakeholder meeting organized by the National Institute for Occupational Safety and Health (NIOSH), that asked similar questions (Albers et al., 2005). As they explained, in the construction sector the ability to control the workplace and work activities is limited by the ever-changing nature of the work. As one manager put it "we don't own the real estate". Another production manager reported: "We don't design the jobs. We execute the jobs". Because of these perceived limitations, most of these interviewees reported that they had adopted innovations limited to those mandated by regulation or the demands of the general contractors on the worksite.

In the larger companies, decision-making that involves a capital expenditure requires more planning, layers of approval, and the ability to justify the cost against overall productivity and efficiency on the one hand, and claims for lost-time injuries on the other (Vedder and Carey, 2005). This was a significant barrier, because as De Jong and Vink (2000) have also noted, it is difficult to establish cost/effort reduction possibilities for innovations to reduce MSDs. As one opinion leaders said:

> The cost would be the primary one and quality would be secondary and then down from there would how long it takes to get the rack on the trucks, how long the trucks are going to be down for. Is this half a day or a whole day? Do I have to get another vehicle? Those are the three primary things I can think of.

However a facilitator to the adopting of innovations to reduce MSDs can be an individual champion who is open to new ideas and to the input from workers. There were at least two reports of employers proactively adopting innovations with respect to ergonomic concerns. One of the companies that had purchased a hydraulic lift before the study was launched was active in implementing changes, regardless of accident rates. In the manager's words:

> We saw the ladder lifts on the vans, and initially we had a meeting with the manufacturer. We had them give a presentation to both of our vice presidents and it made good economic sense. It made good sense from the point of view of health and safety and the preservation of our workers' backs and shoulders. So the decision was made to go ahead and make the switch.

The national health and safety director at one of the largest companies described another ergonomic innovation that focused on shoulder injuries. He told us that workers in his industry had stopped using toolboxes, and had begun to use bags similar to a computer-laptop bag, which could accommodate tools and a laptop. He had identified that these heavy bags were creating shoulder problems, so the company introduced the use of wheeled bags to avoid future problems. He and the workers had jointly identified the problem and the solution.

4.5. Effectiveness of the knowledge transfer (KT) technique

The research showed that knowledge about the hydraulic lifts was diffused in three overlapping areas: the company, the worksite and the industrial sector. The opinion leaders said that they had transferred information on the lifts to other decision-makers in their own companies. Van operators were also identified as sources of knowledge and exhibited the ability to inform workmates that were not employed by their own companies or members of their trade. Finally, the opinion leaders were required as part of the research to share their experiences with their peers at health and safety meetings. At these meetings 32 attendees, who were not part of the original opinion leader group, completed surveys and indicated that the innovation was new to them and they thought it sounded like a good idea.

While the research was designed to evaluate the role of opinion leaders as disseminators of knowledge, it became apparent that they were not the only ones who could be disseminators of the innovation. All the workplace parties could and were involved in KT. In this case, because the workplace parties were involved throughout the process, the KT also took place throughout the process. The KT was not simply the focus of the research but also the result of the research. In this form of applied research, much like participatory action research, KT is an integral component of the research, and not just a final stage of the research.

As a result of this applied research at least 13 companies were initially introduced to an ergonomic intervention. The participants in the research also reached beyond their own 13 companies to at least 32 more companies and each of the thousands of employees of the original 13 companies had the potential to inform several thousand more employees. This study shows that the potential for workplace change can be exponential.

5. Discussion

Despite the positive findings, there were some disappointments. The study was a pilot, and the cost of the innovation was relatively high. This limited the number of ladder lifts that could be bought under the research grant, which affected the uptake and impact of the ergonomic innovation throughout the sector.

There may also have been issues with the choice of the innovation. Firstly, the ladder lift was not used as often in a workday as expected. Secondly, since there is only one worker per service van, and hence no possibility of sharing the innovation, it was not used by enough workers to make a difference on a sectoral level. The intensity of use was certainly too low to either measure an effect on MSDs, or to particularly impress the companies that it could either prevent injuries or improve productivity. This talks strongly to the "relevance" of the chosen innovation.

Unfortunately, the number of companies who wanted to take on the ladder lift, despite no capital cost, was also lower than planned for. This meant that fewer companies were using the innovation. Hence there were fewer opportunities for its exposure to other companies, which limited the possibility for a critical mass of awareness to build which could potentially lead to a "tipping point". But maybe a longer perspective is required, since the adoption of innovations does take time (Van der Molen et al., 2006).

Interestingly, the small and medium-sized companies said the cost of the innovation was not the major barrier. Companies took into account that they always need a ladder rack for their service vans, and the cost of the ladder lift would just add Can $400 to $500 on top of their standard capital investment. Hence those who were considering buying further ladder lifts were either proposing it as a retrofit to their existing racks or as an add-on when new vans were purchased. It is also worth considering the possibility that the greater reluctance of the larger companies may come from their awareness that their decision would involve their whole fleet and not just one van. In the smaller companies, where the owner/operator is often also one of the workers, decision-making is relatively easier.

But the most significant barriers to the adoption of ergonomic innovations may still come down to either a significant lack of awareness of musculoskeletal disorders in this sector, or a lack of confidence to manage MSDs. This is a major barrier that will take a lot of work to break down.

Future research could explore and use the techniques of knowledge transfer to help identify and disseminate innovations to reduce MSDs. The interactionist model of knowledge transfer that advocates for an intense and sustained engagement between those who hold knowledge and those who are potential users of knowledge, and the use of opinion leaders in the diffusion of innovations, could be used to expand the ideas of this pilot study. One idea is to find innovations that are currently being used in the sector. The fact that a company has decided that an innovation is worth investing in, would itself be a large credibility factor. If those companies could be persuaded to be disseminators (opinion leaders) to a larger group of their peers, there could be an increased chance of adoption. These ideas could facilitate the communication of MSD prevention, leading to an eventual reduction in this very painful and disabling health problem.

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References

Albers, J., Estill, C., MacDonald, L., 2005. Identification of ergonomics interventions used to reduce musculoskeletal loading for building installation tasks. Appl. Ergon 36 (4), 427–439.

De Jong, A.M., Vink, P., 2000. The adoption of technological innovations for glaziers: evaluation of a participatory ergonomics approach. Ind. Ergon. 26, 39–46.

Fulmer, S., Azaroof, L.S., Moir, S., 2006. Factors influencing ergonomic intervention in construction: Trunkman case study. New Solutions: J. Environ. Occup. Health Policy 16 (3), 235–247.

Ghobadian, A., Gallear, D., 1997. TQM and organization size. (total quality management). Int. J. Oper. Prod. Manag 16 (1–2), 121–143.

Gogue, T.S., 2007. Ladder loader and bumper hoist prevent injuries. US Navy, Naval Safety Center, Norfolk, VA. http://www.safetycenter.navy.mil/success/stories/0-50/0042.pdf (accessed May 3, 2007).

Hoonakker, P., Loushine, T., Carayon, P., Kallman, J., Kapp, A., Smith, M.J., 2005. The effect of safety initiatives on safety performance: a longitudinal study. Appl. Ergon. 36 (4), 461–469.

Huberman, M., 1994. Research utilization: the state of the art. Knowledge and Policy: Int. J. Knowledge Transfer Util. 7 (4), 13–33.

Jensen, L.K., Friche, C., 2008. Effects of training to implement new working methods to reduce knee strain in floor layers. A two-year follow up. Occup. Environ. Med. 65, 20–27.

Kramer, D.M., Wells, R.P., 2005. Achieving buy-in: building networks to facilitate knowledge transfer. Sci. Commun 26, 428–444.

Kramer, D.M., Cole, D.C., Leithwood, K., 2004. Doing knowledge transfer: engaging management and labour with research on employee health and safety. Bull. Sci. Technol. Soc. 24 (4), 316–330.

Lave, J., Wenger, E., 1988. Cognition in Practice: Mind, Mathematics and Culture in Everyday Life. Cambridge University Press, Cambridge.

Malchaire, J.B., Piette, A., 2002. Co-ordinated strategy of prevention and control of the biomechanical factors associated with the risk of musculoskeletal disorders. Int. Arch. Occup Environ. Health 75, 459–467.

Merlino, L.A., Rosecrance, J.C., Anton, D., Cook, T.M., 2003. Symptoms of musculoskeletal disorders among apprentice construction workers. Appl. Occup. Environ. Hyg. 18 (1), 57–64.

Mitton, C., Adair, C.E., McKenzie, E., Patten, S.B., Perry, B.W., 2007. Knowledge transfer and exchange: review and synthesis of the literature. Milbank Q 85 (4), 729–768.

Moir, S., Paquet, V., Punnett, L., Buchholz, B., Wegman, D., 2003. Making sense of highway construction: a taxonomic framework for ergonomic exposure assessment and intervention research. Appl. Occup. Environ. Hyg. 18 (4), 256–267.

Mollo, V., Falzon, P., 2004. Auto- and allo-confrontation as tools for reflective activities. Appl. Ergonom. 35, 531–540.

Punnett, L., Fine, L.J., Keyserling, W.M., Herrin, G.D., Chaffin, D.B., 1991. Back disorders and nonneutral trunk postures of automobile assembly workers. Scand. J. Work Environ. Health 17 (5), 337–346.

Robson, L.S., Shannon, H.S., Goldenhar, L.M., Hale, A.R., 2001. Guide to Evaluating the Effectiveness of Strategies for Preventing Work Injuries: How to show whether an intervention really works.. United States Department of Health and Human Services, National Institute for Occupational Health and Safety, Centres for Disease Control, Cincinnati, Ohio. http://www.cdc.gov/niosh/docs/2001-119/ (accessed October 20, 2008).

Rogers, E., 2003. Diffusion of Innovation, fifth ed. Free Press, New York.

Schneider, S., 1995. Implementing ergonomics interventions in construction. Appl. Occup. Environ. Hyg. 10 (10), 822–824.

Sexton, M., Barrett, P., Aouad, G., 2006. Motivating small construction companies to adopt new technology. Build. Res. Inform. 34 (1), 11–22.

Sorensen, G., Barbeau, E., Stoddard, A.M., Hunt, M.K., Goldman, R., Smith, A., Brennan, A., Wallace, L., 2006. Tools for health: the efficacy of a tailored

intervention targeted for construction laborers. Cancer Causes Control 18 (1), 51–59.
Spielholz, P., Bao, S., Howard, N., 2001. A practical method for ergonomic and usability evaluation of hand tools: a comparison of three random orbital sander configurations. J. Appl. Occup. Environ. Hyg 16 (11), 1043–1048.
Styhre, A., Josephson, P.-E., Knauseder, I., 2006. Organizational learning in non-writing communities. Manag. Learn 37 (1), 83–100.
Thompson, G.N., Estabrooks, C.A., Degner, L.F., 2006. Clarifying the concepts in knowledge transfer: a literature review. J. Adv. Nurs. 53 (6), 691–701.
Van der Molen, H.F., Koningsveld, E., Haslam, R., Gibb, A., 2005a. Editorial. Ergonomics in building and construction: time for implementation. Appl. Ergon. 36 (4), 387–389.
Van der Molen, H.F., Sluiter, J.K., Frings-Dresen, M.H.W., 2005b. Behavioral change phases of different stakeholders involved in the implementation process of ergonomic measures in bricklaying. Appl. Ergonom. 36 (4), 449–459.
Van der Molen, H.F., Sluiter, J.K., Frings-Dresen, M.H.W., 2006. Is the use of ergonomic measures associated with behavioral change phases? Ergonomics 49 (1), 1–11.
Vedder, J., Carey, E., 2005. A multi-level systems approach for the development of tools, equipment and work processes for the construction industry. Appl. Ergon. 35 (4), 471–480.
Vi, P., Carlan, N., Wells, R., Garritano, E., Bigelow, P., Kramer, D.M., 2007. A pilot study investigating manual material handling of ladders from construction service vans. In: Proceedings of the Association of Canadian Ergonomists. 38th Annual Conference, Toronto, Canada, October 14-17, 2007.