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Transfer activities among Canadian researchers: Evidence in occupational safety and health

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ABSTRACT

The purpose of this paper is to investigate activities of research transfer, the extent of the use of these activities, and the research transfer determinants. This study is based on a population of more than 400 researchers in the field of occupational safety and health (OSH) in Canada, who completed an electronic questionnaire. The results show notably that there is no significant statistical difference between fields for the four activities of research transfer and that several factors have a significant impact on research transfer. Researchers in OSH constituted a rather homogenous unit and can improve the research transfer notably by the adaptation of knowledge, by focusing the research on users' needs and by improving their link with users.

1. Introduction

With regard to the importance of organizational competitiveness, companies unarguably have to aim at performance. This search for perfection and for economy touches all spheres of organizations. To be in front of their competitors, organizations have to become successful in each of their activities. By contributing to the creation and management of new knowledge, innovations and technologies, knowledge transfer constitutes a value for firms and organizations (Landry et al., 2006). The knowledge produced by university research is more and more recognized as a major source for the improvement of the performance of organizations (De Long and Fahey, 2000; Terpstra and Rozell, 1997). However, the return on investments in research is often questioned (Rich, 2002). Indeed, in spite of the large number of research projects in social and health sciences, we notice that a considerable part of this research is not transferred to potential users (Lester, 1993; Lomas, 1997). Public decision-makers, particularly, regret the little impact of research results on public policies and on professional practices (Amara et al., 2003). Furthermore, Lomas (1997) suggests that we are far from knowing what works, in which context and for which type of decision-making.

Despite the presence of many studies in the literature on knowledge and technology transfer, little attention has been given to research transfer in the field of occupational safety and health (OSH). Nevertheless, to remain competitive, companies have no other choice than to value their human resources. They should invest in the recruitment, the training and the retention of their employees. The current successful enterprises are those who have managed to integrate the management of OSH in all the organization's functions (Grawitch et al., 2006).

Occupational safety and health constitutes a recent domain of practice, expertise and research. The burgeoning interest in this question not only concerns organizational performance (Fulmer et al., 2003), but also attests to the growing political and public preoccupations of health among the population (International Labour Organization, 2005). In 2007, in Canada, more than 317,000 new claims for occupational time-loss injuries were filed, of which 1055 were attributable to the fatality of workers (Association of Workers' Compensation Boards of Canada, 2008). Throughout the world, there are globally about 2.2 million work-related deaths annually, according to the ILO estimates for accidents and diseases (International Labour Organization, 2005). All these accidents fuelled consequences not only in terms of loss of life and of disability, but also in terms of social costs and direct and indirect economic costs for employers and society. One estimates to $9.9 billion the cost of professional injuries in Canada (Guzman et al., 2008). In USA, the National Institute of Occupational Safety and Health (NIOSH) assess the direct and indirect cost of injuries to $145 billion, which would be comparable to the cost of AIDS ($33 billion), Alzheimer's disease ($67.3 billion), circulatory diseases ($164.3 billion) and cancer ($170.7 billion) (Guzman et al., 2008). And the European Union estimated that the cost of occupational accidents in EU15 in the year 2000, not including the work-related diseases, was 55 billion euro a year (Eurosafe, 2006).

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To regulate this situation, several authors notice the importance of the research on knowledge transfer in the field of OSH (Goldenhar et al., 2001; Kramer and Cole, 2003; Schulte, 2006; Schulte et al., 2003), on the peculiarities of this research domain (Schulte, 2006), on the research process and its impacts on practices, rules and policies (Schulte, 2006), as well as on the importance of working with new qualitative and quantitative tools to estimate the transfer in OSH (Association of Workers' Compensation Boards of Canada, 2001).

In the last few years, we have witnessed an increase of projects in knowledge transfer in the field of OSH. Among others, the *Canadian Institutes of Health Research* (CIHR) underlined initiatives of knowledge application in occupational health (CIHR Institute of Population and Public Health Canadian Population Health Initiative, 2006). The National Institute for Occupational Safety and Health (NIOSH) from the United States of America also put forward some projects to ensure knowledge application about certain specific risks or in particular sectors.

The transfer of knowledge in OSH is more and more present in the mass media (notably with campaigns of social marketing), professional colloquiums, training programs and scientific conferences. Research projects which have knowledge transfer as an objective are also more numerous. Among those, let us note a study by Kramer and Cole (2003), who estimate factors of efficiency of research transfer and use in OSH with a case study in three companies, and articles led by Paul A. Schulte et al. (2003, 2004), of NIOSH, who was also interested in the study of knowledge transfer in OSH.

The inevitable need for performance of organizations, the sad condition of the workers' health, the human, economic and social costs connected with professional injuries and diseases, the novelty of this domain, the peculiarities of this research field (notably the variety of needs and the multiplicity of the necessary means to fill them) and the meagreness of generalizable evidence on knowledge transfer in OSH justify the study of factors which influence and make effective the transfer of the research results in this domain. Prior studies have contributed to advance our understanding of research transfer in OSH. However, to our knowledge, no study has focused on the research transfer of a large diversity of researchers in numerous research projects in OSH. The purpose of this paper is to investigate activities of research transfer, the extent of the use of these activities, and the research transfer determinants. This paper addresses three questions: First, what is the extent of research transfer in occupational safety and health among Canadian researchers? Second, are there differences between various disciplines and levels of seniority with regard to the extent of this transfer? And third, what are the determinants of research transfer? To answer these questions, the paper identifies the researchers as the unit of analysis of this study and introduces a framework for the identification of determinants of research transfer, from diverse perspectives of knowledge transfer such as the Resource-based view of the firm (Nonaka et al., 2000), the Dissemination Effort Model (Huberman and Thurler, 1991), the knowledge-value chain (Landry et al., 2001b, 2003, 2006, 2007), the Production–Dissemination–Utilization of information Cycle (Schulte et al., 2003) and other models (Abernathy et al., 2001; Amara et al., 2004; Beyer and Trice, 1982; Grant, 1996; Hanney et al., 2003; Innvaer et al., 2002; Kramer and Cole, 2003; Lavis et al., 2003; Lomas, 2000; Scullion, 2002; Weiss, 1979). It defines knowledge transfer and its attributes and shows metric and methods, before presenting results. The last part of the paper outlines implications of results for practice, theory building and public policy.

2. Literature review, metrics and methods

2.1. Unit of analysis and framework

Many studies on research transfer target the number of commercialized technologies as their unit of analysis. In the OSH field, other studies target one project as their unit of analysis and look at both researchers and users. This approach, even pertinent in the way it delves deeply in users' environment, limits the number of projects studied and thus can less be generalized. In this study, we adopted the researcher's perspective by making, as our unit of analysis, the knowledge transferred by researchers. This unit of analysis is especially appropriate to investigate the knowledge transfer of a really mixed population, in which researchers in health disciplines work alongside researchers in social or engineering disciplines. This unit of analysis allows us to examine the knowledge transfer globally in this diversified domain.

Supported by a resource-based approach, Landry and collaborators have developed the knowledge-value chain, which describes the application of knowledge (Landry et al., 2006). In this chain, knowledge progresses from acquisition and mapping to performance and innovation, in the firm. Following these authors, to be applied and to lead to performance, knowledge must go through all those phases. From a researcher's perspective, the first step to cross is the knowledge acquisition by users. In this article, this

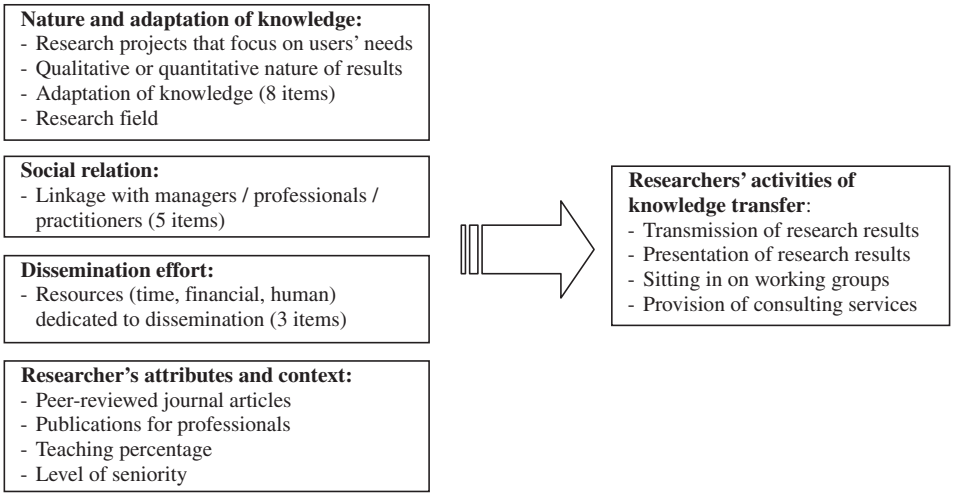

Fig. 1. Factors influencing researchers' knowledge transfer activities in occupational health and safety.

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perspective is used to look at factors that could explain successes of research transfer.

Like Landry et al. (2006), based on the Resource-based approach of firms (Grant, 1996; Nonaka et al., 2000), we assume that researchers have and control resources and capabilities that they use in their transfer activities. In this perspective, when the resources of the researchers increase, the activities of research transfer also increase. Moreover, we believe, like many authors, that the interactions between actors will lead to the success of knowledge transfer (Beyer and Trice, 1982; Dhanaraj et al., 2004; Innvaer et al., 2002; Landry et al., 2006; Lomas, 2000; Rynes et al., 2001; Weiss, 1979; Wenger et al., 2002).

The review of the literature on the knowledge-value chain, the resource-based approach and of other theories or models brought us to classify, in four categories, the factors that are likely to influence the transfer of research knowledge in organizations. It includes (i) the nature and the adaptation of knowledge; (ii) the social relation in the acquisition of knowledge; (iii) the dissemination effort; and (iv) the researcher's attributes and context. The relation between these factors and knowledge transfer is presented in Fig. 1. The variables are next detailed.

2.2. The dependent variable knowledge transfer

The terms knowledge transfer are sometimes used to indicate the transfer of knowledge stemming from research towards workplaces, and other times in reference to the transfer of knowledge between organizations (inter-organizational) or in reference to the transfer of knowledge between various actors of a workplace (intra-organizational). In the present article, knowledge transfer is studied as the exchange of results between researchers and workplaces.

Moreover, some researchers use in a similar way the terms "knowledge transfer" and "technology transfer" (Amesse and Cohendet, 2001; Oliver and Liebeskind, 1998), arguing that the creation of new knowledge implies the understanding and the absorption of certain new technologies (Gopalakrishnan and Santoro, 2004, p. 57). However, although connected, knowledge transfer and technological transfer are two different concepts, which also include different activities (Gopalakrishnan and Santoro, 2004, p. 58). Knowledge transfer would be a wider concept, which answers more the question of "why", while technology transfer would be a narrow and more precise concept, which includes tools to change the environment and which corresponds more to the understanding of "how" (Gopalakrishnan and Santoro, 2004). In this paper, we follow Gopalakrishnan and Santoro (2004, p. 57), and use knowledge transfer as a different concept from technological transfer. Knowledge transfer is neither used as knowledge dissemination, nor as knowledge utilization or application. We define knowledge transfer as the process of transfer between researchers and users. This transmission can take place with more tacit (less tangible) or more explicit (tangible) knowledge. These attributes of knowledge suggest the use of a process approach, in which we identify how the knowledge produced across different stages of the research process is moved into the different users' activities (Landry et al., 2001b, 2003, 2007; Lomas, 1997).

As Landry et al. (2007), we inspired our measure on Knott and Wildavskys' scale (1980), which assumes knowledge transfer (KT) is a series of activities rather than the exchange of a tangible technological product. The scale used in this study includes the four activities of knowledge transfer presented in Table 1. Both unidimensionality and internal consistency of the scale were assessed by using a principal component factor analysis and Cronbach's α (see Section 3.1). Respondents were asked to assess how frequently they engaged in each activity over the last 5 years, using a 5-point scale ranging from 1 (never) to 5 (very often).

2.3. Explanatory variables of knowledge transfer

From our literature review, we highlighted different determinants of the knowledge transfer in OSH. They are presented in this section in four categories.

2.3.1. Nature and adaptation of knowledge

Several authors identified elements linked with the nature and the adaptation of the knowledge as having an impact on the efficiency of the transfer (Amara et al., 2004; Beyer and Trice, 1982; Hanney et al., 2003; Innvaer et al., 2002; Landry et al., 2001b, 2003; Lavis et al., 2003; National Center for the Dissemination of Disability Research, 1996; Scullion, 2002). Among those factors, let us note a clear language, the presence of a summary, the presence of variables manipulable by users, the sensitivity to users' needs, the specific and operational nature of conclusions and recommendations, the profitability of results, the importance of supplying data on the efficiency of research results and the attractive aspect of documents (graphics, color, packaging, etc.). Besides, some researchers highlight the importance of the type of results (qualitative or quantitative) for the success of knowledge transfer (Amara et al., 2004; Landry et al., 2001a,b, 2003). However, as a general rule, we do not find, in the literature, a consensus on the evidence of the greater efficiency of the qualitative or quantitative studies. The majority of these various identified variables can be found in the *Knowledge-Driven Model*, the *Technological Model*, the *Engineering Model* or the *Problem-Solving Model*.

In this study, researchers' assessments regarding the extent to which their research projects are focused on users' needs (USERN) or on the advancement of scientific knowledge are measured on a 5-point Likert scale. Respondents were asked to assess which of the statements best describes their research projects over the last 5 years, ranging from 1 (almost exclusively focused on users' needs) to 5 (almost exclusively focused on the advancement of scientific knowledge). The type of results (qualitative or quantitative) produced by researchers (QUQUAN) was also measured on a 5-point Likert scale, ranging from 1 (almost only qualitative results)

Table 1
Activities of knowledge transfer (KT).

Activity 1	*Transmission of research results*	I have sent my research results to organizations (e.g., firms, departments, hospitals, not-for-profit) outside the academic milieu
Activity 2	*Presentation of research results*	I have been invited to present my research results to organizations (e.g., firms, departments, hospitals, not-for-profit) who could make direct use of them
Activity 3	*Sitting in on working groups involving users*	I have been asked to sit in on working groups that were involved in efforts to directly apply new knowledge, including my own research
Activity 4	*Provision of consulting services*	I have provided consulting services to organizations (e.g., firms, departments, hospitals, not-for-profit) associated with my research field

Adapted from Knott and Wildavsky (1980) and from Landry et al. (2001a,b, 2003, 2007).

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to 5 (almost only quantitative results). The degree of adaptation of research results (ADAPT) was measured by using an eight-item index regarding (i) the presentation of research results in non-technical language, (ii) the supplying of examples or demonstrations of how to use research results, (iii) the preparation of documents and products that were appealing, (iv) the preparation of reports on specific topics, (v) the discussion of implications of research results for users, (vi) the supplying of abstracts of research results, (vii) the presentation of results in a way that managers/professionals/practitioners can adapt variables or results to their context and needs, and (viii) the supplying of information on research results' efficacy and profitability. For each statement, respondents were asked to assess whether they adapted their research results for managers/professionals/practitioners in these ways over the last 5 years, using a 5-point scale ranging from 1 (never) to 5 (very often). Hence, the varying degree of adaptation of research results is measured by the sum of the scores of items corresponding to responses to these eight assertions. Scores of the respondents, which initially ranged from 8 to 40, were weighted in order to take into account "does not apply" answers. Thus, for each respondent, the sum of the scores was divided by the number of applicable items. Even though the initial index has integer values from 1 to 5, once weighted, it can take on non-integer values.

In this paper, research fields were measured with a series of binary variables defined as follows: ENGIN is a binary variable coded 1 if the respondent was a researcher in natural sciences and engineering, and 0 otherwise; SOCIAL is a binary variable coded 1 if the respondent was a researcher in anthropology, communication, labour law, psychology, industrial relations, sociology, economic, educational sciences and administrative sciences, and 0 otherwise; READAP is a binary variable coded 1 if the respondent was a researcher in ergonomics, rehabilitation and kinesiology, and 0 otherwise; MEDSC is a binary variable coded 1 if the respondent was a researcher in epidemiology, medical sciences, public health and nurse sciences, and 0 otherwise. This last category of researchers was used as the reference category in the regression model. Respondents were asked to assess in which discipline they mainly work, by rating from 1 to a maximum of 3 disciplines (1 being their main discipline and 3 being the less important discipline). The first discipline was retained for the analysis.

2.3.2. Social relation in the acquisition of knowledge

Various authors identify the meagerness of the links between researchers and practitioners, professionals or decision-makers. For Lomas (2000), part of the transfer problem lies in the difference of culture which surrounds those who do research and those who have to use it. For Hanney and his co-workers, values and different interests characterize both groups, and this is what would provoke this lack of natural relations between researchers and users (Hanney et al., 2003). However, several authors think that the existence of interactions between actors is a token of success for the knowledge transfer (Rynes et al., 2001). Moreover, authors (Sales et al., 2006) believe in the efficiency of using theories about the change of behaviour for the elaboration of specific interventions. In a different way, Dhanaraj et al. (2004) demonstrate the importance of social links in knowledge transfer. Also, Beyer, Innvaer and their co-workers suggested the importance of interrelations between researchers and users in the determination of the variables of knowledge use (Beyer and Trice, 1982; Innvaer et al., 2002). Finally, let us note that Lomas (2000, p. 236) thinks that a philosophy of "linkage and exchange" is a promising way to increase the efficiency of the use of research in health services.

The *Interactive Model*, or *Social Interactive Model*, is at the heart of the reflections of the majority of authors who underline the importance of relations in knowledge acquisition. Let us be reminded that in this non-linear model, the use of the research represents only a part of a complex process where the researcher interacts with various actors (practitioners, politicians, customers, etc.) to gradually arrive at an answer for the decision-maker (Weiss, 1979). Another point of interest in the study of the links between actors is the *Social Learning Theory* and its application by means of the study of communities of practice (Wenger et al., 2002). Therefore, one of the major determinants of knowledge transfer is the links between researchers and users, and must be introduced in our study.

In this paper, the level of social capital (LINK) was measured by using an index assessing the intensity of the linkages that the researcher had with managers and/or professionals from five types of organizations: (i) Private firms; (ii) Government prevention institutions (commissions, legislation, etc.); (iii) Government departments/agencies (Ministries, Para-public firms); (iv) Trade unions; and (v) Non-profit organizations (groups or associations, etc.). For each type of organization, respondents were asked to assess how frequently they had person-to-person contact with managers/professionals/practitioners, using a 5-point scale ranging from 1 (never) to 5 (very often). The social capital index is thus the sum of the scores of the items corresponding to the researcher's responses. Respondents' scores, which initially ranged from 5 to 25, were weighted in order to take into account "does not apply" answers. Thus, for each respondent, the sum of the score was divided by the number of applicable items. Even though the initial index ranges from 1 to 5, once weighted, it can take on non-integer values.

2.3.3. Dissemination effort

This aspect of knowledge transfer is underlined notably in the *Dissemination Effort Model* presented by Huberman and Thurler (1991). This model considers the user not as a passive element to be educated, but rather as a recipient framework with particular dynamics (Huberman and Thurler, 1991, p. 184) and in which efforts of dissemination have to come from researchers, and also from users (p. 185). In this model, the dissemination of knowledge is studied as an explanatory variable of a phenomenon. This model highlights the importance of the researchers' total time investment for dissemination (p. 167), and of time dedicated to different activities and phases of dissemination (p. 169). So, this model suggests the influence of the availability of resources (p. 175). The various variables connected with the dissemination effort have to be part of a study which tries to underline knowledge transfer from the research to the organizations.

In this paper, the resources dedicated to dissemination (RESDISS) are measured by using a three-item index regarding (i) the time, (ii) the financial resources, and (iii) the human resources dedicated to the dissemination of research results. For each statement, respondents were asked to assess how frequently, in planning their projects, they dedicate those resources to dissemination, using a 5-point scale ranging from 1 (never) to 5 (very often). Hence, the varying degrees of resources dedicated to dissemination are measured by the sum of the scores of the items corresponding to the responses to these three assertions. Scores of the respondents, which initially ranged from 3 to 15, were weighted in order to take into account "does not apply" answers. Thus, for each respondent, the sum of the scores was divided by the number of applicable items. Even though the initial index has integer values from 1 to 5, once weighted, it can take on non-integer values.

2.3.4. Researchers' attributes and context

For the same research and the same public, we proposed in the literature that factors connected to the source and to the context of the source (researchers) could influence knowledge transfer. Among others, Huberman and Thurler (1991) highlighted various determinants of transfer connected to the researchers'

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organizational factors. They noted, particularly, that the integration of researchers in their organization (level of seniority of researcher and orientations of his institution) could have an influence on knowledge transfer. In the evaluation of researcher's context, by basing themselves on the *Science-Push Model*, other authors identify the total number of publications as a determining factor of transfer (Landry et al., 2001a, 2001b). To explain knowledge transfer and identify the independent variables, researchers based themselves on the *Resource-based Theory of Firms* (Landry et al., 2007). To the variables previously mentioned, the authors add, as determinants of transfer, the number of teaching hours dedicated to the education and training of students.

In this article, the researcher's publications (SRPUB) are measured as the total number of peer-reviewed journal articles (including those as first author) published during the last 5 years. The researcher's publication asset is also measured by the total number of reports published (LNREP) during the last 5 years. Furthermore, involvement in teaching is measured as the percentage of time spent by the researcher on teaching activities (SQTEACH). Finally, the level of seniority in the academic ranks is measured as follows: full professor (FULL) is a binary variable coded 1 if the researcher is a full professor, and coded 0 otherwise; associate professor (ASSOC) is a binary variable coded 1 if the researcher is an associate professor, and coded 0 otherwise; assistant professor (ASSIST) is a binary variable coded 1 if the researcher is an assistant professor, and coded 0 otherwise; grantee researcher (GRANTEE) is a binary variable coded 1 if the researcher is not tenured and if his salary is supported by research grants, and coded 0 otherwise; and scientific professional (PROFESS) is a binary variable coded 1 if the researcher' salary is supported by the research grants of others, and coded 0 otherwise.

Based on this rationale and prior empirical studies on research knowledge transfer, 10 hypotheses were formulated (Table 2). They were afterwards verified by statistical analysis.

2.4. Sample

This study is based on a 2007 survey of 568 researchers in occupational safety and health in Canada. The data was collected with a web-based survey. It was impossible to work with a single complete existing bank of all researchers in this field, simply because such a bank does not exist. The list of the participants was thus constituted from membership lists of different researchers' institutions and groups. At first, an initial list of 404 researchers was constituted. Thereafter, this list was enriched to obtain a final number of participants of 568 researchers.

The initial list of 404 participants was constituted from researchers' public lists available on the Internet. A list of 372 people was found on the site of the *Canadian Association for Research on Work and Health* (CARWH). To this list were added the full (74) and associate (32) members of the *Quebec Occupational Safety and Health Research Network* (RRSSTQ), the researchers from the *Institute for Work and Health* (IWH) (57) and the *Institut de recherche Robert-Sauvé en santé et en sécurité du travail* (IRSST) (42). This initial list was completed with 57 OSH researchers of the *British Columbia Environmental and Occupational Health Research Network* (BCEOHRN). On the whole, the established initial list counted 634 persons (372 + 106 + 57 + 42 + 57). After, a study of the profiles (institution, department, research interests, addresses, e-mail) of those 634 persons was made. This exercise allowed us to identify 105 persons who appeared more than once in the list and doubles were removed. Also, it was identified that 17 researchers did not come from Canada, 74 persons were not researchers, and 34 persons were identified as masters and Ph.D. students, so they were all removed from the list. Let us note that the postdoctoral students were preserved in the list. This led to 404 as the final number of persons from the initial list of the OSH researchers in Canada.

Then, given that it was likely that researchers of the OSH domain did not appear in this initial list (the membership of the CARWH, the RRSSTQ and the BCEOHRN being notably conceived on a voluntary base), it became necessary to verify if the bank of 404 researchers was fairly complete. To do this, a list of 104 Internet links towards national and provincial research organizations in OSH made available by the *Canadian Centre for Occupational Health and Safety* was used. By going through these sites, 164 researchers who were not part of the initial list were identified. It brought to 568 (404 + 164) the number of researchers identified in the OSH domain in Canada. As a final check, to make sure that every person who would answer the questionnaire was really a Canadian researcher in the OSH field, at the beginning of the questionnaire, the participants had to answer the following question: "In the last 5 years, have you done research in the field of occupational health and safety?" The participants answering "no" to the question could not pursue the questionnaire.

A questionnaire was sent to the 568 researchers identified. The questionnaire was forwarded at the participants' professional e-mail addresses. The questionnaire was created by means of the software *Enterprise Feedback Management* (EFM Feedback), produced by *Vovici*. The data were automatically aggregated in the software and were exported in SPSS format. The researchers could answer the questionnaire in French, or in English. The results of the questionnaires of both languages were analyzed jointly. Before sending, the questionnaire was pre-tested.

3. Results

Of the 568 researchers included in the study, 134 were excluded from the sample for the following reasons: doubles ($n = 1$), wrong e-mail addresses ($n = 23$), "no" response to the first question ($n = 71$), and other reasons such as being retired, does no more research or OSH, etc. ($n = 39$). Also, 13 researchers were added to the sample as suggested by respondents (question 36 of the questionnaire). The final sample thus comprised 447 researchers. Of these, 10 refused to participate and 220 did not complete the

Table 2
Research hypotheses.

H1	The greater the extent to which researchers' projects focus on users' needs, the higher their knowledge transfer activities are
H2	The type of results (qualitative vs quantitative) produced by researchers does not affect their transfer activities
H3	When researchers adapt their research knowledge, it increases their knowledge transfer activities
H4	The researchers operating in engineering will exhibit a higher level of knowledge transfer activities than researchers in other fields (social sciences, rehabilitation sciences and medical sciences)
H5	The stronger the linkages between researchers and potential users are, the higher the knowledge transfer activities of researchers are
H6	The higher the researchers' resources incurred in dissemination efforts are, the higher their knowledge transfer activities are
H7	The higher the number of peer-reviewed journal articles published by researchers is, the higher the knowledge transfer activities of researchers are
H8	The higher the number of research reports published is, the higher the knowledge transfer activities of researchers are
H9	The greater the percentage of researchers' teaching hours is, the lower their knowledge transfer activities are
H10	The higher the academic rank of researchers is, the higher their knowledge transfer activities are

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questionnaire (after three recalls). Finally, the survey generated 217 usable questionnaires for a net response rate of 48.5% (217/447).

3.1. Dependant and independent variables

For the dependent and independent variables, based on multiple-item scales and included in the econometric model, we conducted a principal components factor analysis (PCFA) on the construct scales to assess their unidimensionality (Ahire and Devaray, 2001). For the dependent variable knowledge transfer (KT), the result of the PCFA indicates that one factor explains 50.15% of the original variance of the phenomenon studied with an initial Eigenvalue of 2.006. For the three independent variables based on multiple-item scales, namely the index referring to the adaptation of knowledge (eight items), the linkage with managers/professionals/practitioners (five items), and the resources dedicated to dissemination (three items), the results of the PCFA indicate that, in all cases, one factor explains, respectively, 46.47%, 42.63% and 83.61% of the original variance of these three constructs. Once the unidimensionality of the additive scales measuring the three independent variables based on multiple-item scales was established, an assessment of the statistical reliability was necessary. In order to make such an assessment, an item analysis of the components of these additive scales was performed by computing Chronbach's α. This coefficient provides a reliability coefficient for multiple-item scales, such as those included in the scales of the four variables. The Chronbach's α is 0.658 for the four items of knowledge transfer (KT), 0.838 for the eight items of the adaptation index, 0.659 for the five items of the linkage index and 0.901 for the three items of the resources dedicated to the dissemination index. Hence, the values of the α coefficients for multiple-item scales employed in this study are reliable (Ahire and Devaray, 2001; Nunally, 1967, 1978).

Furthermore, we used the probability plots to determine whether the distribution of each of the seven continuous variables included in the model matches a normal distribution. More specifically, we used the *Q*–*Q* plots procedure, which plots the quintiles of a variable's distribution against the quintiles of a normal distribution. In doing so, we found that the variables knowledge transfer activities, adaptation, resources dedicated to dissemination and linkage did not differ significantly from a normal distribution. In fact, the observations of these variables are clustered around a straight line, corresponding to normal distributions. For the three other continuous variables included in the model, namely the peer-reviewed journal articles, the research reports published and the teaching percentage, we found that the observations are not clustered around a straight line corresponding to normal distributions. For these three variables, we used a square roots or logarithm transformation; the probability plots for the transformed values indicated that the transformed variables did not differ significantly from a normal distribution.

Finally, the correlation matrix between the independent variables used in the regression model indicates that the highest correlation coefficient between the independent variables is that existing between the variable adaptation (ADAPT) and the variable referring to the linkage with users (LINK). This correlation coefficient is equal to 0.427, which ensures that no serious multi-collinearity problems can arise in the regression model.

The statistics of the variables used in this study are reported in Table 3.

3.2. Descriptive and bivariated analysis

In this paper, the process of research transfer is operationally defined as including four activities: transmission of research results, presentation of research results, sitting in on working groups involving users, and provision of consulting services. Each of these

Table 3
Descriptive Statistics.

Variables	Type of variables	Min.	Max.	Mean	Standard deviation	Cronbach's ∞
Continuous variables						
Knowledge transfer activities	Index: four items	1	5	2.78	0.81	0.658
Adaptation of knowledge	Index: eight items	1	5	3.20	0.74	0.838
Linkage with users	Index: five items	1	5	2.92	0.77	0.659
Resources dedicated to dissemination	Index: three items	1	5	3.35	1.11	0.901
Peer-reviewed journal articles	Continuous	0	56	11.29	11.51	–
Reports	Continuous	0	58	5.11	7.20	–
Teaching percentage	Continuous	0	71.43	17.46	16.35	–
Categorical variables						
Research projects that focus on users' needs	• Almost only focused on users' needs.					6.1%
	• Mainly focused on users' needs					16.5%
	• Half on users' needs and half on advancement of knowledge.					48.1%
	• Mainly focused on the advancement of knowledge					21.7%
	• Almost only focused on the advancement of knowledge					7.5%
Qualitative or quantitative nature of results	• Almost only qualitative results					6.2%
	• Mainly qualitative results, but also some quantitative results					17.1%
	• Half qualitative results and half quantitative results					19.9%
	• Mainly quantitative results, but also some qualitative results					25.1%
	• Almost only quantitative results					29.9%
Research field	• Natural Sciences and Engineering					24.5%
	• Social Sciences					22.7%
	• Rehabilitation Sciences					20.4%
	• Medical Sciences					32.4%
Level of seniority	• Full professor					29.0%
	• Associate professor					19.2%
	• Assistant professor					15.9%
	• Grantee researcher					15.9%
	• Scientific professional					20.1%

Note: Number of researchers = 217.

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activities was defined in Table 1. The computation of the answers to the questions on knowledge transfer shows that about 31% of the researchers surveyed often or very often sent research results outside the research milieu. Conversely, 14.3% of the respondents never sent research results to users outside the research milieu. Similarly, 33.6% of the respondents indicated that they had often or very often been invited to present research results to groups and organizations which could make direct use of them. At the next stage, 20% of the respondents had often or very often been asked to sit in on working groups that were involved in efforts to directly apply new knowledge, which included their own research. The results of Table 4 also show that 17.5% of the researchers surveyed had often or very often provided consulting services to organizations associated with their research field. Globally, the average of the index (four items) of research transfer indicates a mean of 2.78 (on a 1–5 scale), thus indicating a research transfer degree by OSH researchers of nearly 3 (sometimes).

Moreover, we used the Chi-square test to compare the proportion of researchers who have transferred knowledge, over the past 5 years, according to research fields, and according to levels of seniority. The results (in Table 5) show that there is no significant statistical difference between fields for the four activities of research transfer (transmission of research results, presentation of research results, sitting in on working groups, provided consulting services). To compare the level of global knowledge transfer index across research fields, we used a oneway ANOVA. The results of the test indicate that there is no significant statistical difference between fields with regard to the level of knowledge transfer activities (global index) ($p = 0.483$). Overall, these results confirm that research fields don't seem to matter, that is to say that researchers in different fields are nearly similarly active in knowledge transfer.

Also, the results (Table 6) show that there is no significant statistical difference between levels of seniority for three activities of research transfer (transmission of research results, presentation of research results and provided consulting services). However, the levels of seniority are significantly different between groups for the sitting in on working groups variable (two-tailed p-value of 0.039). For the global knowledge transfer index across levels of seniority, the results of the oneway ANOVA indicate that there is no significant statistical difference between levels of seniority with regard to the level of knowledge transfer activities ($p = 0.173$). Overall, these results confirm that levels of seniority do not matter, that is to say that the researchers with a certain status were not more active in knowledge transfer activities than those with another status.

3.3. Regression results

To study the impact of explanatory variables on the dependent variable, we developed the following ordinary least squares model:

$$\begin{aligned} KT = {} & \beta_0 + \beta_1\ USERN + \beta_2\ QUQUAN + \beta_3\ ADAPT + \beta_4\ ENGIN \\ & + \beta_5\ SOCIAL + \beta_6\ READAP + \beta_7\ LINK + \beta_8\ RESDISS \\ & + \beta_9\ SRPUB + \beta_{10}\ LNREP + \beta_{11}\ SQTEACH + \beta_{12}\ ASSOC \\ & + \beta_{13}\ ASSIST + \beta_{14}\ GRANTEE + \beta_{15}\ PROFESS + \varepsilon \end{aligned}$$

Table 4
Frequency distribution of knowledge transfer activities and average of the global index.

How frequently have you engaged in the following activities over the last 5 years?	Scale measurement (in % of researchers)						Median (mode)
	Not applicable/Missing data	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Very often (5)	
Transmission of research results	2.3	14.3	19.4	33.2	17.5	13.4	3.00 (3)
Presentation of research results	2.3	8.8	15.2	40.1	23.0	10.6	3.00 (3)
Sitting in on working groups	3.2	21.7	21.7	33.2	14.3	6.0	3.00 (3)
Provided consulting services	2.3	24.9	26.3	29.0	12.4	5.1	2.00 (3)
Global research transfer index				**Average 1–5 scale (SD)**			**2.78** (**0.81**)

SD: Standard deviation.

Table 5
Frequency distribution of the categorical variables measuring knowledge transfer activities by researchers' fields.

How frequently have you engaged in the following activities over the last 5 years?	Scale measurement (in % of researchers)						Mean rank	Kruskal–Wallis statistics
	Not Applicable/Missing data	Never	Rarely	Sometimes	Often	Very often		
Transmission of research results								
Natural Sciences and Engineering	2.8%	17.6	19.6	35.3	11.8	15.7	101.73	1.077
Social Sciences		12.8	23.4	25.5	14.9	23.4	112.62	
Rehabilitation Sciences		11.4	20.5	43.2	20.5	4.5	102.02	
Medical Sciences		15.9	17.4	31.9	23.2	11.6	107.19	
Presentation of research results								
Natural Sciences and Engineering	2.8%	9.8	19.6	35.3	29.4	5.9	101.60	2.422
Social Sciences		8.5	14.9	31.9	25.5	19.1	116.73	
Rehabilitation Sciences		11.4	13.6	47.7	18.2	9.1	99.53	
Medical Sciences		7.2	14.5	46.4	21.7	10.1	106.07	
Sitting in on working groups								
Natural Sciences and Engineering	3.7%	27.5	23.5	23.5	19.6	5.9	101.31	3.417
Social Sciences		26.1	19.6	39.3	8.7	6.5	100.00	
Rehabilitation Sciences		25.0	22.7	38.6	9.1	4.5	98.05	
Medical Sciences		14.7	23.5	35.3	19.1	7.4	115.65	
Provided consulting services								
Natural Sciences and Engineering	2.8%	26.9	25.0	23.1	21.2	3.8	108.52	2.552
Social Sciences		29.8	23.4	29.8	12.8	4.3	102.70	
Rehabilitation Sciences		25.0	38.6	27.3	4.5	4.5	95.67	
Medical Sciences		22.1	23.5	35.3	11.8	7.4	113.04	

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where $\beta_i (i = 0, \ldots, 15)$ are the coefficients and ε is an error term.

This model was estimated for research transfer as a whole (four items). After the verification of the colinearity, homoscedasticity, normal distribution of the continuous independent variables, residual normality and models' linearity assumptions, we obtained the results presented in Table 7. It can be seen that the focus of the research projects on users' needs, the adaptation of knowledge, the linkage with users, the resources dedicated to dissemination and the number of research reports published were explanatory variables that were significantly and positively related to knowledge transfer activities. Another variable included in the model were

Table 6
Frequency distribution of the categorical variables measuring knowledge transfer activities by researchers' levels of seniority.

How frequently have you engaged in the following activities over the last 5 years?	Scale measurement (in % of researchers)						Mean rank	Kruskal–Wallis statistics
	Not applicable/missing data	Never	Rarely	Sometimes	Often	Very often		
Transmission of research results								
Full professor	3.7%	15.0	23.3	30.0	16.7	15.0	102.49	2.378
Associate professor		17.9	15.4	35.9	25.6	5.1	100.45	
Assistant professor		9.1	27.3	33.3	15.2	15.2	105.00	
Grantee researcher		17.6	20.6	35.3	8.8	17.6	99.66	
Scientific professional		11.6	11.6	37.2	23.3	16.3	116.85	
Presentation of research results								
Full professor	3.7%	6.7	20.0	35.0	25.0	13.3	107.61	7.267
Associate professor		0.0	12.8	46.2	23.1	17.9	121.03	
Assistant professor		6.1	12.1	45.5	24.2	12.1	111.05	
Grantee researcher		17.6	11.8	44.1	17.6	8.8	93.54	
Scientific professional		14.0	18.6	39.5	25.6	2.3	91.24	
Sitting in on working groups								
Full professor	4.6%	21.7	15.0	36.7	11.7	15.0	113.30	10.096**
Associate professor		15.4	17.9	33.3	30.8	2.6	118.82	
Assistant professor		12.1	30.3	45.5	9.1	3.0	104.24	
Grantee researcher		27.3	27.3	24.2	15.2	6.1	95.42	
Scientific professional		31.0	28.6	31.0	9.5	0.0	83.50	
Provided consulting services								
Full professor	3.7%	21.3	31.1	31.1	11.5	4.9	106.16	7.094
Associate professor		12.8	23.1	41.0	12.8	10.3	124.55	
Assistant professor		27.3	21.2	36.4	15.2	0.0	103.77	
Grantee researcher		41.2	20.6	20.6	11.8	5.9	90.59	
Scientific professional		28.6	33.3	19.0	14.3	4.8	97.79	

** $p \leqslant 0.05$.

Table 7
Regression equation predicting degree of research transfer activities.

Dependent variables: research transfer activities (index of four items)		
Independent variables	Coefficients (β)	p-Value
Nature and adaptation of knowledge		
Research projects that focus on users' needs [USERN}	0.140	0.029**
Qualitative or quantitative nature of results [QUQUAN]	0.015	0.815
Adaptation of knowledge (eight items) [ADAPT]	0.440	0.000***
Natural Sc. and Engineering as Research fields [ENGIN]	−0.102	0.127
Social Sciences as Research fields [SOCIAL][a]	−0.076	0.273
Rehabilitation Sciences as Research fields [READAP][a]	−0.179	0.009***
Social relation in the acquisition of knowledge		
Linkage with users (five items) [LINK]	0.168	0.007***
Dissemination effort		
Resources dedicated to dissemination (three items) [RESDISS]	0.125	0.054*
Researcher's attributes and context		
Peer-reviewed journal articles [SRPUB][b]	0.092	0.181
Number of research reports [LNREP][b]	0.114	0.060*
Teaching percentage [SQTEACH][b]	0.091	0.218
Associate professor as level of seniority [ASSOC][c]	0.031	0.633
Assistant professor as level of seniority [ASSIST][c]	0.012	0.851
Grantee researcher as level of seniority [GRANTEE][c]	−0.056	0.434
Scientific professional as level of seniority [PROFESS][c]	−0.090	0.271
Number of cases: 187		
Adjusted R^2: 0.443		

[a] With Medical Sciences as reference category.
[b] The square roots transformation of the variable whose name it precedes.
[c] With Full professor as reference category.
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

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significantly and negatively related to knowledge transfer: being in rehabilitation sciences instead of in medical sciences. The other variables included in the model, namely, the qualitative or quantitative nature of results, being in natural sciences and engineering, being in social sciences, the number of peer-reviewed journal articles, the teaching percentage, being an associate professor, an assistant professor, a grantee researcher or a scientific professional were found to be non-related to knowledge transfer.

The value of the adjusted R^2 is 0.443, which is the degree of variance in the magnitude of knowledge transfer explained by this model.

Furthermore, the degree of signification of the model is 0.000, which suggests that the null hypothesis, that all the parameter coefficients (except the intercept) are all zeros, is strongly rejected. Consequently, the model is significant at the 1% level.

4. Conclusion and discussion

This paper has presented a model of how researchers in occupational safety and health (OSH) transfer knowledge outside the research community. Evaluating transfer with concrete activities of knowledge transfer, this paper thus adds to the relatively scarce evidence about research transfer by examining research transfer from a broader perspective than strict commercialization.

The findings of this paper show that researchers were active in the transfer of their research knowledge. Furthermore, the fact that knowledge transfer increased as the number of research reports increased suggests the importance of such documents in OSH. However, the number of peer-reviewed articles seems to have no significant impact on knowledge transfer activities. This result goes against our hypothesis and other research results that state that the number of publications is a determining factor of transfer by social sciences researchers (Landry et al., 2001a,b). Moreover, the results show that researchers who focus on users' needs transfer significantly more than those who focus on the advancement of knowledge. Indeed, this indicates that the greater the extent to which researchers' projects focus on the users' needs, the higher their knowledge transfer activities are.

Three other variables have a positive and significant impact on research transfer by Canadian researchers in the OSH field, namely the adaptation of knowledge, the resources dedicated to dissemination and the linkage with users. The index utilized to measure adaptation was used for the first time, and thus constituted a contribution to the development of a new quantitative tool to estimate the transfer in OSH and its determinants.

In our regression model, to be in rehabilitation sciences as research field, in reference to the medical sciences fields seems to have a significant negative impact on research transfer. However, not significant, the same negative impact has been shown in the results of social sciences, natural sciences and engineering. Thus, in OSH, with the interference of other variables, researchers operating in medical science field seem to exhibit a higher level of knowledge transfer activities than researchers in other fields. The results are also interesting for the researchers' level of seniority. Against our prediction, the researchers' level of seniority not seems to matter in the way they use knowledge transfer activities.

Because of the researcher's perspective used in this research, other variables related to the context and the nature of users were not included in this study as determinant of knowledge transfer. Future researches in knowledge transfer in the OSH field should therefore look at the determinants of research implementation among users, using an organizational perspective.

Some other limits could restrict the application of our study. First, no complete list of researchers in OSH in Canada does exist. Thus, we cannot be sure that our initial population was complete. Also, the number of respondents could limit the analysis and the variables significance. At last, our study is not a direct measure of transfer, but of transfer activities, and it does not take into account indirect links between independent variables.

These results have some very practical implications. First, given the frequency of research transfer, more attention should be paid to the users' needs in the definition of research objectives. Funding councils should continue and optimize the opportunities for researchers to focus on users' needs. Second, universities and other research organizations should take into account the fact that the adaptation of knowledge is good predictor of research transfer activities. They could support researchers in adapting their research results. Third, although the number of peer-reviewed articles does not have a significant impact on research transfer, we believe that knowledge transfer activities must not jeopardize researchers' scientific activities related to the advancement of knowledge. Finally, researchers in the OSH field seem to have a high level of linkage with users. The importance of this variable is also demonstrated through its impact on research transfer. Researchers should continue to maintain person-to-person contacts with managers, professionals and practitioners. This suggests also the importance for organization to open their activities to researchers and to look for collaborations and linkages. In addition, by the definition of their needs and the identification of problems to solve, organizations could contribute to the orientation of research projects which will help them improve the health and safety of workers.

A lot of research in occupational safety and health is produced each year around the world. Even if the society and the workplaces has been changing over the years (Beck, 2003; Beck and Beck-Gernsheim, 1995; Giddens, 1991, 2004; Lyotard, 1979; Sennett, 2000), and that we still need evidences on new risks and new ways to manage them, much knowledge are not applied in organizations and still many injuries occur each day. The knowledge transfer is one approach, nevertheless not the only one, which aims to reduce the number of death and injuries at work. This study focused on how we can improve the knowledge translation in OSH, from the researcher's perspective. The next step will be to explore how we can increase the application of knowledge in the workplaces.

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