

# FIVE-YEAR SCIENTIFIC AND TECHNICAL PRODUCTION PLAN

# 2018-2022



Institut de recherche  
Robert-Sauvé en santé  
et en sécurité du travail

## **PRODUCTION**

### **Scientific Division**

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## **LEGAL DEPOSIT**

Bibliothèque et Archives nationales du Québec  
2018  
ISSN : 0820-8409  
ISBN 978-2-89631-996-1

[irsst.qc.ca](http://irsst.qc.ca)

# FOREWORD

This strategic plan constitutes the IRSST's roadmap for the next five years, making it the cornerstone for all our future actions. It sets the objectives to be attained and traces the path that will be taken by each of our research fields (Sustainable Prevention and Work Environment, Chemical and Biological Hazard Prevention, Mechanical and Physical Risk Prevention, and Occupational Rehabilitation) over the 2018-2022 period.

The development of this plan required broad consultation with our partners in the world of work, including the Commission des normes, de l'équité, de la santé et de la sécurité du travail (CNESST), the scientific community, and the clientele served by our laboratories, as well as contributions from IRSST staff. Only through such a process can it truly meet the needs expressed for advancement of knowledge in the field of industrial accident and occupational disease prevention and of occupational rehabilitation of injured workers. This five-year plan, which is designed to address the main concerns of the CNESST, management and labour organizations, professional associations, and members of the scientific and technical community, reflects the research and expertise priorities of Québec workplaces. While self-contained, the plan also leaves the IRSST sufficient leeway to respond to specific needs and emerging problems that may be

brought to its attention during the new five-year cycle. Such a plan does not materialize automatically, spontaneously, or thoughtlessly. Rather, it requires the efforts of many parties who make invaluable and distinct contributions. I therefore wish to offer my sincere thanks to all those who had a hand in its preparation, and to underscore the vital and leading role played by the members of our Scientific Advisory Board, which represents employers, workers, and the scientific community. Their open and constructive participation in this iterative process helped produce an enhanced document.

That said, however viable its content, a plan remains just that. The IRSST must now operationalize this plan by carrying out the proposed research projects and knowledge transfer activities by 2023. On behalf of all IRSST staff, it is with great pride that I undertake to rigorously monitor our progress along the path ahead and to ensure that the mission entrusted to our organization is carried out: that of contributing, through research, to the prevention of industrial accidents and occupational diseases and to the rehabilitation of affected workers.

We firmly believe in this mission and pursue it with steadfast enthusiasm, in full collaboration with our partners.

**Marie Larue**  
President and CEO  
IRSST



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# ACRONYMS AND INITIALISMS

ACFAS	Association francophone pour le savoir
AIHA	American Industrial Hygiene Association
ANSES	Agence française de sécurité sanitaire de l'environnement et du travail
AQHSST	Association québécoise pour l'hygiène, la santé et la sécurité du travail
ASP	Joint sector-based association
ASTM	American Society for Testing and Materials
BAuA	Federal Institute for Occupational Safety and Health (Germany)
CBHP	Chemical and Biological Hazard Prevention
CEAEQ	Centre d'expertise en analyse environnementale du Québec
CEL	Controlled environment laboratory
CIH	Certified Industrial Hygienist
CIHR	Canadian Institutes of Health Research
CKTD	Communications and Knowledge Transfer Division
CLAS	Calibration Laboratory Assessment Service
CNESST	Commission des normes, de l'équité, de la santé et de la sécurité du travail
DGUV	German Social Accident Insurance
ELAP	Environmental Laboratory Approval Program
ETS	École de technologie supérieure
EU-OSHA	European Agency for Safety and Health at Work
FIOH	Finnish Institute of Occupational Health
FRQS	Fonds de recherche du Québec – Health
FTE	Full-time equivalent
HEC	Hautes études commerciales de Montréal
HLLS	Horizontal lifeline system
HPD	Hearing protection device (or hearing protector)
HSE	Health and Safety Executive (United Kingdom)
ICAR	Shared infrastructure for acoustics research
ICOH/CIST	International Commission on Occupational Health – Commission internationale de la santé au travail
IFA	Institute for Occupational Safety and Health of the German Social Accident Insurance (Germany)
INRS	Institut national de recherche et de sécurité (France)
INSPQ	Institut national de santé publique du Québec
IOSH	Institution of Occupational Safety and Health (United Kingdom)
IRSST	Institut de recherche Robert-Sauvé en santé et en sécurité du travail
ISCRR	Institute for Safety Compensation and Recovery Research (Australia)
ISO	International Organization for Standardization
ISQ	Institut de la statistique du Québec
ISSA	International Social Security Association
IWH	Institute for Work & Health (Ontario, Canada)

KT	Knowledge translation
LIMS	Laboratory Information Management System – Système de gestion des analyses de laboratoire
MESI	Ministère de l'Économie, de la Science et de l'Innovation (Québec)
MPRP	Mechanical and Physical Risk Prevention
MSDs	Musculoskeletal disorders
NIOSH	National Institute for Occupational Safety and Health (United States)
NOC	National Occupational Classification
NRC	National Research Council Canada
NRCWE	National Research Centre for the Working Environment (Denmark)
OCRC	Occupational Cancer Research Centre
OEDC	Organisation for Economic Co-operation and Development
OHS	Occupational health and safety
OSHA	Occupational Safety and Health Administration (United States)
PPE	Personal Protective Equipment
PPMI	Permanent physical or mental impairment
QLSCD	Québec Longitudinal Study of Child Development
REPAR	Réseau provincial de recherche en adaptation-réadaptation
ROHS	Regulation respecting occupational health and safety (Québec)
RPD	Respiratory protective device
RTW	Return to work
SAAQ	Société de l'assurance automobile du Québec
SCCI	Safety Code for the Construction Industry (Québec)
SELF	Société d'ergonomie de langue française
SEs	Small enterprises
SIAS	Safety of Industrial Automated Systems
SJR	Sustainable Job Retention
SKSG	Statistical Knowledge and Surveillance Group
SPWE	Sustainable Prevention and Work Environment
SSHRC	Social Sciences and Humanities Research Council (Canada)
SWA	Safe Work Australia
TEM	Transmission electron microscope
TLI	Accepted (or compensated) time-loss injury
TNO	Netherlands Organisation for Applied Scientific Research
TrA	Traumatic accident
UQAM	Université du Québec à Montréal
UQTR	Université du Québec à Trois-Rivières
VGQ	Auditor General of Québec / Vérificateur général du Québec
WHO	World Health Organization
WRASQ(L) <sup>TM</sup>	Work-related Asthma Screening Questionnaire – Long Version <sup>TM</sup>
WRTA	Work-related traffic accident
WSBC	WorkSafeBC (British Columbia)

# 1. INTRODUCTION

The 2018-2022 Five-Year Plan is presented to you here following broad consultation with the IRSST's advisory bodies and its social and scientific partners. It is based primarily on the following inputs: the scientific monitoring and statistical surveillance work of the IRSST's Scientific Division, the knowledge development needs identified by the scientific community, and the needs expressed by our partners in the workplace.

This plan puts into perspective the research efforts that will be required in each of the IRSST's four priority research fields over the next five years, as well as the organizational strategies that will need to be implemented to achieve the Institute's mission.

The statistical portrait of CNESST-accepted occupational injuries reveals a continuation of the downward trend already observed during the previous five-year cycle (2013-2017), despite the growing number of workers in the Québec labour force. However, we have also witnessed an increase in certain types of injuries, including occupational diseases, and in cases of hearing loss in particular. Moreover, the proportion of women and workers aged 55 years or older found among victims of accepted injuries increased more than their proportion in the labour force. Injuries involving rehabilitation represent less than 10% of all accepted injuries, but account for nearly 60% of the CNESST's payouts. The number of fatalities fluctuates with no clear trend, standing at around 200 a year. Fatalities are more often the result of occupational diseases than of industrial accidents. These data, combined with those presented for each of the research fields, will enable us to establish priorities among our research activities.

It is important to remember that the changes observed in the sociodemographic and technological contexts of the work world will generate major issues within the

next few years, especially at the level of the labour force, in terms not only of its availability and aging but also of the growing number of immigrant workers. All this is set against a backdrop of intensifying implementation of technologies being generated by Industry 4.0. As an occupational health and safety (OHS) research centre, the IRSST is a key player in bringing together and supporting the advancement of new knowledge, ultimately to ensure its uptake and application by workplaces. Its practices for disseminating research findings and transferring knowledge will therefore be re-examined from a continuous improvement perspective in order to identify the best strategies for optimizing the benefits of scientific work in the workplace and measuring to what extent the desired effects are achieved.

For each research field and in the light of current knowledge, needs expressed by workplaces, and statistical analyses of occupational injuries, the plan proposes a research program focused on various themes<sup>1</sup> or specific thematic programs<sup>2</sup> that are deemed priority.

Moreover, as a funding organization, the IRSST intends to embark, over the next few years, on a reflection process aimed at optimizing the funding application submission and analysis process, ultimately to accelerate the handling of applications insofar as possible.

In addition, the IRSST's laboratories will continue developing new analytical methods in order to enhance the services they offer to the CNESST and its network, while also participating in research and development activities to support the carrying out of scientific projects.

Staff participation will be sought and encouraged to expand the Institute's reach and reputation and ensure that its research findings are disseminated in specialized publications, or shared and discussed at major scientific

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<sup>1</sup> A theme refers to a research sector for which the Institute hopes to support projects that are likely to meet knowledge advancement needs identified by its social partners or the scientific community.

<sup>2</sup> A thematic program refers to a structured research strategy that consists of tackling a theme through the planning (generally for the medium term) of a set of complementary projects designed to meet a specific need.

events or in standardization committees. These events in fact provide excellent networking opportunities, potentially leading to new partnerships that could well increase the Institute's research capacity.

Faced with a major turnover in its own workforce due to the numerous retirements anticipated over the next few

years, the IRSST plans to develop a range of recruitment and training initiatives to fill a variety of research and management positions as they become vacant. Lastly, sustained efforts will also be needed to cultivate a new generation of external OHS researchers who can fill the void left by upcoming retirements in universities.

# 2. DESCRIPTION OF THE RESEARCH FIELDS, PROGRAMS, AND PLANNING TOOLS

Over the new five-year cycle, it is proposed that research be further developed in the four existing fields:

- Sustainable Prevention and Work Environment
- Chemical and Biological Hazard Prevention
- Mechanical and Physical Risk Prevention, and
- Occupational Rehabilitation

The following sections describe the characteristics of each of these research fields in terms of their goals, research

orientations, current thematic programs and research themes, and those proposed for development. For each field, the priority issues are put into perspective based on statistical data for compensated occupational injuries and fatalities, and on research mapping and scientific monitoring, while taking into account needs expressed by the Institute's social partners. This chapter concludes with a presentation of the statistical surveillance, scientific monitoring, and outreach activities anticipated by the IRSST to ensure optimal research planning within its various fields.





# 2.1 SUSTAINABLE PREVENTION AND WORK ENVIRONMENT



## CONTEXT

Over the next five years, the labour market will be affected primarily by changing sociodemographic and technological contexts. The aging of the population will only accelerate. According to OECD data (2016), the ratio of the elderly population to the working age population will nearly have doubled by 2020, resulting in major labour force availability issues. Better use of the labour force, in particular by involving older workers, young people, and immigrants, is envisaged to address this eventuality. This will in turn lead to the “cohabitation” of diverse worker populations in the same workplaces. According to Statistics Canada data (*Labour Force Survey*, 2015) from 1995 to 2015, the employment rate in Québec increased by 20% among young workers aged 15 to 19, by 43% among workers aged 55 to 59, by 86% among those aged 60 to 64, by 156% among those aged 65 to 69, and by 177% among workers aged 70 and over. In addition, from 2006 to 2015, the participation rate of immigrants in the Québec labour force rose from 11% to 14%. This proportion increased from 19% to 25% in the Montréal Census Metropolitan Area (CMA). Moreover, from 2005 to 2015, the employment rate was up by 13.1% among women and by 8.3% among men.

Regarding changes by economic activity sector, the average annual growth rate of employment in the services industry was up, while that of certain other sectors (manufacturing, primary, and construction) was down (2002 to 2015). The distribution of employees by establishment size in Québec in 2015 was as follows: 30.5% in establishments with fewer than 20 employees, 34.0% in establishments with 20 to 99 employees, 20.5% in establishments with 100 to 500 employees, and 15.0% in establishments with more than 500 employees.

Furthermore, the fourth industrial revolution, well under way since 2011 following German reflections on Industry 4.0, is characterized by the use of new technologies arising from digital and artificial intelligence developments. The main related issues concern management methods, the labour force, and the trend toward service-centred

business models (Québec’s Ministère de l’Économie, de la Science et de l’Innovation (MESI)). In Canada, nearly 9% of jobs are at high risk of automation (Arntz and Zierahn, 2016). This concerns highly repetitive jobs in particular and affects mostly workers with little schooling. A number of jobs will also see some of their tasks totally transformed by these technological changes. This trend is gradually polarizing the labour market, where the demand for labour is increasing for highly skilled jobs involving the use of the new technologies and for unskilled jobs that are difficult to automate. In addition, technological advances are making it possible to fragment complex tasks into multiple tasks, which promotes the development of on-demand or atypical jobs (temporary, part-time, and self-employed). In Québec, in 2016, 37% of jobs were atypical (temporary or part-time [fewer than 30 hours a week] and self-employed jobs). According to the *Labour Force Survey of Canada* (LFS), a temporary job is one that has a predetermined end date or that will end as soon as a given project is completed. This definition includes seasonal jobs, temporary jobs (i.e. for a predetermined period or on contract, including work done through a placement agency), casual jobs, and other temporary jobs.

In Québec, again in 2016, approximately 14% of jobs (just under 500,000) were temporary. Of these, 23% were seasonal jobs, 54% were term or contract jobs, 22% were casual jobs, and 1% were other types of temporary jobs. This proportion has tended to hold steady for the past 20 years, but fluctuates according to economic cycles. The proportion of temporary jobs also tends to vary, depending on the various characteristics of the labour force (age, sex) and of the job, including the economic activity sector.

In 2016, temporary jobs represented 11.2% of all jobs in the goods-producing sector. This proportion increased to 14.2% in the services sector. Proportionally speaking, the educational services sector had the largest number of temporary workers (30.2%), followed by the information, culture, and recreation (25.8%), agriculture (25.4%) and

business, building, and other support services (24.0%) sectors.

According to Québec's Ministère de l'Économie, de la Science et de l'Innovation, in order to deal with technological changes, small and medium-sized enterprises (SMEs) in the manufacturing sector will have to meet challenges involving the re-engineering of working methods and processes as well as the development of new competencies. These challenges will require investments in labour force training and will transform operational and management methods and behaviours. In Québec, from 2010 to 2012, more than seven enterprises out of ten introduced a technological innovation, i.e. a product or process innovation encompassing goods production and distribution methods (*Survey of Innovation and Business Strategy – Manufacturing Sector*, Québec 2010-2012).

For its part, the Business Innovation Observatory of the European Commission states, in its trend report entitled *Disruptive Innovations and Forward-looking Policies towards Smart Value Chains*, that collaborative robots (cobots) will make major headway in the years ahead. It anticipates that cobots will not only improve the quality of working life by relieving workers of monotonous and dangerous tasks, but also substantially increase company productivity. In addition, their flexibility and adaptability make them attractive technologies for first-time robot users and for SMEs. Since 2010, the installation of robots has been on the rise in Canada. According to the International Federation of Robotics ([https://ifr.org/downloads/press/Executive\\_Summary\\_WR\\_2017\\_Industrial\\_Robots.pdf](https://ifr.org/downloads/press/Executive_Summary_WR_2017_Industrial_Robots.pdf)), the annual supply of industrial robots in North America will increase on average by 5% to 10% a year from 2016 to 2019. Collaborative robots will lead this market.

These trends in the changing demographic and technological contexts pose challenges with regard to the integration of new workers and sustainable job retention, challenges that require competency development, labour force training, and the adjustment of work situations.

## GOAL

In the previous five-year plan, the research perspectives of the Sustainable Prevention and Work Environment (SPWE) field reflected a by-injury approach, with particular emphasis on the prevention of musculoskeletal disorders (MSDs).

Several studies conducted during the 2013-2017 cycle (for example, as part of the MSD thematic program on emergency call centres and on secondary school and CEGEP students who combine work and studies) highlighted the simultaneous occurrence of different occupational injuries in workplaces and the presence of risk and protective factors common to these injuries.

For the new five-year cycle, the SPWE field will therefore favour a global approach to occupational injury prevention. That said, some of the proposed thematic programs or research themes have identified contexts conducive to the study of specific injuries.

The goal of this field is to enhance understanding of the social, demographic, organizational, and technological factors that have an impact on the occurrence of occupational injuries, from a sustainable prevention perspective, ultimately to foster sustainable job retention.

The development of OHS management tools and workplace intervention practices is an important goal, as is the development and application of measurement methods and evaluation tools through the use of metrics and biomechanical modelling, questionnaires, and surveys.

## RESEARCH ORIENTATIONS

The activities conducted in the SPWE research field revolve around three main orientations:

1. Analysis of the impacts of organizational, demographic, and technological changes within enterprises, on occupational health and safety
2. Development and application of measurement methods and evaluation tools (measurement of exposure and of risk and protection factors; activity analysis; surveys; and data collection tools)
3. Interventions pertinent to, and management of, OHS problems (case management process and tools, integration of OHS into design, adjustment of work situations)

## 2.1.1 PUTTING THE FIELD'S PRIORITY ISSUES INTO PERSPECTIVE BASED ON STATISTICAL DATA

Over the 2010-2012 period, an average of 92,400 occupational injuries were accepted by the CNESST annually. Three-quarters of this number resulted in compensated time-loss injuries (TLIs). Of all accepted injuries, 61.0% involved traumatic accidents, 33.6% involved musculoskeletal disorders (MSDs), and 5.4%, "other" injuries, essentially occupational diseases. Also from 2010 to 2012, stress-related injuries represented 1.5% of the compensated TLIs, or an average of 1,042 injuries per year, while violence-related injuries represented 2.2% of compensated TLIs, or an average of slightly over 1,500 injuries per year.

During this same period, just under 7 million days were compensated for TLIs each year, including 54% for traumatic accidents, 45% for MSDs, and 1% for other types of injury. The average durations of compensation varied, depending on the type of injury, and stood at 87.2 days for traumatic accidents, 121.2 days for MSDs, and 325.5 days for other types of injury. The annual cost of occupational injuries in Québec was thus estimated at \$4.84 billion (in 2011 dollars), including 52.3% generated by traumatic accidents, 24.2% by MSDs, and 23.5% by other types of injury (essentially occupational diseases). The "other" category of injury represented only 5.4% of the accepted injuries, but 23.5% of the total costs.

Since the end of the 1980s, the number of TLIs has continued to decline, a trend observed in both Québec and the rest of Canada. Thus, despite the big increase seen in the mid-1980s, the annual number of TLIs dropped by 57.1% in Québec and by 44.7% in all the other provinces and territories of Canada from 1982 to 2012. For the 2007-2012 period, the total number of CNESST-accepted injuries decreased from just over 112,700 to less than 90,600, representing a drop of slightly more than 22,000 injuries. This significant drop corresponds to an average annual variation of -4.4%. Also from 2007 to 2012, work-related accidents dropped by an average of 4.8% per year, while occupational diseases increased by an average of 2.7% per year. From 2004 to 2014, the number of accepted violence-related injuries with income replacement indemnities (IRIs) remained relatively stable (decrease of 7%) compared to the total number of accepted injuries with IRIs in Québec, which dropped by nearly 40%. In other words, the relative proportion of this problem grew from 1.5% to 2.3%. From 2006 to 2014, the number of accepted stress-related injuries with IRIs (drop of 28%) essentially followed the same pattern as the total number of injuries in Québec (drop of 30%). Proportionally speaking, this problem thus remained stable at around 1.4% over this period.

Despite a decline in the number of accepted injuries during the 2007-2012 period, the aggregate cost held steady owing to the increase in the average cost per injury. The average cost of an occupational injury (in 2012 constant dollars) rose from \$28,014 to \$34,869. This significant hike corresponds to \$1,457 per year.

During the 2010-2012 period, more than 66% of compensated TLIs occurred among men versus nearly 34% among women. This situation is largely attributable to the fact that a greater proportion of men worked in manual occupations (40% versus 13%) and that there were more men than women present in the labour market, particularly if the number of hours worked are factored in (55% versus 45% full-time equivalent (FTE) frequency rate). For each of the three main occupational categories (manual, non-manual, and mixed), women had a higher FTE frequency/severity rate than men. The average duration of compensation was also higher among women in the three occupational categories. However, the gaps in compensation duration between women and men were greatly reduced relative to the 2005-2007 period, and durations were even similar in the case of manual workers. Injury severity, in terms of permanent physical and mental impairment (PPMI), was higher among men than women. The differences by sex, in terms of frequency and severity of compensated occupational TLIs, stem partly from the fact and that men and women were not distributed equally across the occupations and that the types of injury involving men, as well as their characteristics, were different from those involving women.

Among workers aged 15 to 24 years, the average annual number of compensated TLIs was 8,600 (2010-2012). Taking into account the number of hours worked, three-quarters of these TLIs involved workers aged 20 to 24. The average annual number of sick days per worker (FTE frequency/severity rate) among young workers was clearly below that of the labour force as a whole. The same is true when sex and occupational category are taken into account. This result is essentially due to the fact that average compensation durations were twice as short among young people.

Also during the 2010-2012 period, for workers aged 55 or older, the average annual number of compensated TLIs was more than 10,000. Taking into account the number of hours worked, 93% of these TLIs involved workers aged 55 to 64 years. What further differentiates the occupational injuries sustained by workers aged 55 and older from workers as a whole are the severity indicators. The average compensation duration among older workers was nearly

six weeks longer than that of the labour force as a whole. Moreover, injuries sustained by workers in this age group were much more frequently accompanied by a PPMI, and the average PPMI rate for this group was higher, regardless

of sex or occupational category. The average PPMI rate for workers aged 65 and older was 50% higher than for workers aged 55 to 64.

## 2.1.2 PUTTING THE FIELD'S PRIORITY ISSUES INTO PERSPECTIVE BASED ON RESEARCH MAPPING AND SCIENTIFIC MONITORING AND SURVEILLANCE

An overview was produced of studies conducted around the world during the 2011 to 2016 period to put into perspective the social, demographic, organizational, and technological factors having an impact on the occurrence of occupational injuries, the management of OHS, intervention practices in the workplace, and the development and application of measurement methods and evaluation tools. Six organizations were retained in the Sustainable Prevention and Work Environment (SPWE) field: the National Institute for Occupational Safety and Health (NIOSH) in the United States, the Institut national de recherche et de sécurité (INRS) in France, the Federal Institute for Occupational Safety and Health (BAuA) in Germany, the Finnish Institute of Occupational Health (FIOH), WorkSafeBC (WSBC) in British Columbia, and the IRSST. A total of 249 studies were documented.

Analysis of these research mappings revealed that 45% of the studies focused on analyzing the effects of organizational, demographic, and technological changes within companies on occupational health and safety. Three institutes stood out in this regard: the IRSST, FIOH, and NIOSH, with 26%, 24%, and 23% of the studies respectively. In all the studies investigating these issues, it was organizational aspects (58% of the cases) and demographic aspects (28% of the cases) that were the most frequently studied, particularly working and employment conditions, the organizational environment, and age-related demographic aspects (older and young

workers). The socioeconomic aspects were more often broached in terms of the influence of new regulations on OHS. The effect of technological changes on OHS was found to be an emerging topic of study.

Nearly 58% of the documented studies were aimed at developing and applying measurement methods and evaluation tools. More specifically, 61% of them concerned evaluation and the measurement of risk factors, while 18% looked at the effectiveness of transformations or interventions in the workplace. Of the studies that sought to develop measurement methods and tools, 35% concerned ambulatory systems and biomechanical modelling. The IRSST stood out for its efforts in these areas.

In addition, intervention and OHS management practices in the workplace were examined in 35% of the studies, mainly by the IRSST and NIOSH. An ergonomic perspective was adopted in 80% of the studies looking at intervention practices. Of the studies on OHS management, 29% focused on the implementation of prevention programs and 24% on training in the workplace.

The knowledge reviews produced during the 2013-2017 cycle underscore the relevance of studying, from a sustainable prevention perspective, the questions related to management and OHS and to the factors associated with sustainable job retention. It also appears that the impact of introducing cobots (which include powered exoskeletons) on OHS is an emerging and inescapable topic.

### 2.1.3 PUTTING THE FIELD'S PRIORITY ISSUES INTO PERSPECTIVE BASED ON NEEDS EXPRESSED BY PARTNERS

The partners consulted during this strategic planning exercise also voiced certain concerns and research interests regarding the impact of social, demographic, organizational, and technological factors on the occurrence of occupational injuries.

Regarding demographic changes affecting workplaces, the issues of the aging labour force and the increase in health problems such as musculoskeletal disorders, psychosocial disorders, and chronic diseases, are of concern to several partners. They expressed needs regarding ways to intervene; adjust work situations; and supervise, support, and train this aging labour force in order to keep them at work. OHS issues related to precarious employment, particularly workers in the education sector and temporary foreign workers in the agriculture sector, were also raised.

Our partners cited concerns about how to mobilize and promote more OHS management initiatives in small and medium-sized enterprises, particularly in the care, services, agriculture, and fishing sectors. The development

of an OHS culture and the role of managers and coaches with regard to OHS were cited as topics of interest. Several partners mentioned the effect of work overload on OHS and on the means of prevention needed in this context.

Also mentioned was the question of continuing the work aimed at integrating OHS more effectively into working methods or means, and during organizational or regulatory changes that may affect working situations and exposure to certain risks. Studies on manual handling also continue to be of interest.

Regarding technological changes, the partners seem more concerned about the mental workload they can generate, the control measures they allow, and their effects, notably on psychological health.

Lastly, the need to be able to evaluate the effectiveness, effect, and benefits of prevention measures, OHS training, and interventions in the workplace was expressed.

### 2.1.4 RESEARCH PROGRAMS AND THEMES

The strategic planning of research in this field is presented in four sections: current thematic programs, thematic programs to be developed, current themes, and themes to be developed. It is proposed to continue developing the three current thematic programs and to give a new orientation to two programs that were anticipated in

the preceding five-year plan. It is also proposed that other work in this field be grouped under eight research themes (tables 1 and 2). As mentioned earlier, these are aimed at a global approach to the sustainable prevention of occupational injuries. However, some of the related contexts may be conducive to the study of specific injuries.

**Table 1** Developments and changes anticipated for the 2018-2022 five-year period

THEMATIC PROGRAMS	
<b>To continue (current)</b>	<b>To develop</b>
<ul style="list-style-type: none"> <li>• Material handling</li> <li>• Work-related road accidents</li> <li>• MSDs related to office automation</li> </ul>	<ul style="list-style-type: none"> <li>• Integration of young workers into the labour market (reorientation of the Young Workers Aged 15 to 19 and OHS program)</li> <li>• OHS in small enterprises</li> </ul>
RESEARCH THEME	
<b>To continue (current)</b>	<b>To develop</b>
<ul style="list-style-type: none"> <li>• Knowledge transmission and training</li> </ul>	<ul style="list-style-type: none"> <li>• Cohabitation of diverse populations in the workplace</li> <li>• Digital revolution (4.0): opportunities and risks</li> <li>• OHS issues arising from the growth in services</li> <li>• Development of methods for evaluating exposure and assessing risk</li> <li>• Evaluation of interventions in the workplace</li> <li>• Prevention cultures and OHS</li> <li>• Prevention and aging</li> </ul>

**Table 2** Breakdown of programs and themes by the field’s research orientations

	ORIENTATION 1	ORIENTATION 2	ORIENTATION 3
<b>CURRENT THEMATIC PROGRAMS</b>			
Material handling			x
Work-related road accidents			x
MSDs related to office automation			x
<b>THEMATIC PROGRAMS TO BE DEVELOPED</b>			
Integration of young workers into the labour market	x		
OHS in small enterprises			x
<b>CURRENT RESEARCH THEME</b>			
Knowledge transmission and training	x		
<b>RESEARCH THEMES TO BE DEVELOPED</b>			
Cohabitation of diverse populations in the workplace	x		
Digital revolution (4.0): opportunities and risks	x		
OHS issues arising from the growth in services	x		
Development of methods for evaluating exposure evaluation and assessing risks		x	
Evaluation of interventions in the workplace		x	
Prevention cultures and OHS			x
Prevention and aging			x



## 2.1.4.1 CURRENT THEMATIC PROGRAMS

### 2.1.4.1.1 MATERIAL HANDLING



#### Aims

In Québec, in 2011, slightly more than 35,000 workers held jobs as material handlers. Moreover, of all the MSDs accepted by the CNESST from 2010 to 2014, 53% were associated with this type of job.

The program on material handling principles focuses on training, but training is regarded as a doorway to encouraging prevention and actions for transforming the determinants of work situations involving equipment, layout, organization of the work, etc. It is a matter of developing a new approach better adapted to the work realities, of training trainers, and of doing follow-up on the training sessions they in turn give in the workplace to ensure that any necessary changes are made.

#### Progress report

This program has progressed by 80%. Following the development of the material handling training program, the study entitled *Implantation d'une stratégie intégrée de prévention en manutention* [implementation of an integrated prevention strategy in material handling], commonly called *Formation de formateurs* [training

trainers], was completed. Continuing along these lines, a study was begun in 2017 to design learning exercises based on material handling principles for new material handlers. Its goal is to facilitate the uptake of principles during training by developing learning aids that help material handlers acquire the right habits and movements.

In addition, as anticipated in the 2013-2017 five-year plan, the posture dosimeter is now being field-tested in the context of a study on a system for measuring material handlers' physical exposure to MSD risks. This activity fits in with the project on training trainers as it seeks to develop and test a system for quantitatively measuring material handlers' physical exposure in the workplace. During the final phase of the current thematic program, the ambulatory method developed may therefore be used during evaluation of the effectiveness of prevention approaches.

Moreover, the study on the strategies used by obese material handlers has been completed.

#### Developments anticipated during the cycle

The work currently under way will be completed. The last phase of this program will consist of evaluating the effects of implementing training in workplaces. In light of the results of the *Critical Literature Review on Material Handling Training Quality*, it is anticipated that the evaluation will not be limited to measuring biomechanical exposure, but rather will include other dimensions, which in turn will raise other issues and methodological challenges with respect to the more global evaluation of MSD prevention interventions. Thought will therefore have to be given to the types of effects to evaluate and to the possibility of adopting a multi-pronged process incorporating performance indicators and cognitive and perceptual motor approaches, for example.

### 2.1.4.1.2 WORK-RELATED ROAD ACCIDENTS

#### Aims

Approximately 2% of all workers compensated by the CNESST receive these benefits following a work-related road accident (WRRAs). Yet these accidents constitute the leading cause of accidental work-related deaths (from 25% to 30%). Given this worrisome statistic, the IRSST first funded a literature review to learn more about the risk factors associated with WRRAs (Messier, Bellavance and Duguay, 2013) and a descriptive study of compensation data recorded concurrently by the Société de l'assurance

automobile du Québec (SAAQ) and the CSST (Pignatelli, Bellavance and Duguay, 2013).

The research program on work-related road accidents was proposed and accepted in spring 2015. Its general aim is to improve understanding of the determinants of WRRAs and to develop, implement, and evaluate intervention and prevention strategies in the target populations.

To stimulate research on WRRAs prevention, the IRSST issued a call for proposals for the purpose of attaining

two objectives: gaining a better understanding of WRRRA determinants; and determining, implementing, and eventually evaluating possible interventions for preventing them.

Based on the priorities identified by partners and the reflections of the IRSST’s Scientific Division, four topics were retained for this call for proposals.

1. Practices promoting the prevention of WRRAs in SMEs and large enterprises
2. Organization of work and WRRAs
3. Learning to drive safely in the work context
4. Driving support tools designed to prevent WRRAs

**Progress report**

Following the call for proposals, two projects were selected and are currently in progress. First, the study on WRRAs and pedestrian workers is examining the relationships between work environments, situations posing a road accident risk, and the daily stress levels of pedestrian workers. This study should shed more light on the determinants and circumstances of WRRAs involving pedestrian workers, and propose improvements, particularly with respect to

work organization. Second, the aim of the study on OHS problems in cyclist workers is to document the rise in bicycle delivery services and occupations, as well as the current forms of work organization. The researchers also hope to document the road accident risks associated with delivery work and cases of accidents and near-misses, and to define the various factors involved. This information should point to prevention measures and to good practices that could be used to improve the safety of cyclist workers.

**Developments anticipated during the cycle**

The current work will be completed. An activity on the cost of work-related road accidents that occurred in Québec from 2000 to 2013 will be piloted by the Statistical Knowledge and Surveillance Group. The results will provide a new and original overview of the economic consequences of WRRAs in Québec. The various analyses performed will, among other things, identify the groups of workers and the accident circumstances associated with the highest costs. In addition, efforts will be made to stimulate research related to this thematic program. To increase the pool of researchers who might be interested, it would therefore be relevant to consider developing an interfield program out of this theme.

**2.1.4.1.3 MSDS RELATED TO OFFICE AUTOMATION**

**Aims**

The prevalence of MSDs in worker populations that use computers remains a problem, and prolonged work on a computer is associated with musculoskeletal symptoms, particularly in the neck and forearms. The ever-rising use of computers in the workplace and in leisure activities points to the likelihood that this problem will increase significantly, and implies an urgent need to study the phenomenon. For example, in Québec, the proportion of workers confirming that they use computers at work was 30% in 1989, but 50% in 2000 (Poussart, 2002). More recent data (Vézina et al., 2011) indicate that nearly 20% of workers spend 31 or more hours a week on the computer in their main job.

**Progress report**

To encourage the prevention of MSDs in the office automation context in Québec, this program is broken into

two phases: first, the continuation of the study aimed at documenting the promising practices of practitioners and the practices implemented in workplaces, and second, the production of a best practices guide.

The first phase of this program aimed at forming an overview of prevention practices in the office automation context has been completed. The second phase, that of producing a best practices guide, was also completed at the end of the 2013-2017 cycle.

**Developments anticipated during the cycle**

As announced during the 2013-2017 cycle, the program may be completed by the implementation and evaluation of this best practices guide. Given that the researchers involved have since retired, a new team will have to be formed to continue this program. Strategies will also have to be developed to identify new research priorities for this still-current theme.



## 2.1.4.2 THEMATIC PROGRAMS TO BE DEVELOPED

### 2.1.4.2.1 INTEGRATION OF YOUNG WORKERS INTO THE LABOUR MARKET

#### Aims

In Québec, young workers are entering the labour market at ever-younger ages, and student participation is on the rise. In 2013, to support the production of new knowledge on the work performed by adolescents and on OHS, the IRSST became a financial partner in the *Québec Longitudinal Study of Child Development (QLSCD)* with a view to incorporating into it a new series of questions on employment and occupational health and safety (OHS) (2011-0026, 2013-0086).



#### Progress report

In addition to completing the work planned in the Young Workers and OHS program, to date the IRSST has participated in the last two data collection activities in Phase 3 of the QLSCD (young workers aged 15 and 17), whose aim was to track young people throughout their secondary school years. The Institute also contributed to the first activity in Phase 4 (young workers aged 19) that tracks young people as they transition to adulthood, i.e. up to the age of 25.

A portrait of young workers aged 15 was produced and presented in a booklet published jointly with the ISQ. Another study concerning the risk factors and developmental trajectories associated with early entry into the labour market at the age of 13 and on the repercussions on the OHS of young people holding jobs at age 15 is currently in progress.

#### Developments anticipated during the cycle

It is anticipated that the Young Workers Ages 15 to 19 and OHS program planned in the previous cycle will be reoriented by focusing it on the utilization of the QLSCD's full potential. This will allow for a first study in Québec of the integration of young workers into the labour market and OHS using longitudinal data.

### 2.1.4.2.2 OHS IN SMALL ENTERPRISES

#### Aims

On the structural level, it is important to remember that small enterprises (SEs) of 50 workers or fewer are at the heart of the Canadian and Québec economies. According to the figures from the *Enquête québécoise sur des conditions de travail, d'emploi et de SST* [Québec survey on working and employment conditions and occupational health and safety], 45.3% of the labour force (including management, salaried employees, and self-employed workers) work for a small enterprise with 50 workers or fewer. It is also SEs that contribute the most to job growth in Canada. The interest in OHS research in SEs is shared by the international scientific community.

#### Progress report

Using databases of information relevant to forming an overview of the situation, comparative analyses were done of the work context and a statistical portrait was formed of OHS problems by enterprise size. Meetings were held among researchers in the field to lay the foundations for a

strategy aimed at developing a thematic program on OHS in small enterprises.

#### Developments anticipated during the cycle

It is anticipated that the development of this program, announced during the previous cycle, will be reoriented toward integrated prevention in small enterprises by working in collaboration with the Occupational Rehabilitation field. This reorientation is based on the assumption that targeting prevention and return-to-work (RTW) objectives simultaneously while developing intervention approaches in SEs could have positive effects on the receptiveness of both stakeholders and enterprises, and on the sustainability of the impacts of these interventions. It is often the same factors that cause the weaknesses in prevention and difficult returns to work in SEs. It appears that the research on prevention and on RTW interventions could be developed jointly, which would also be advantageous for the actors in small enterprises.

### 2.1.4.3 CURRENT THEME

#### 2.1.4.3.1 KNOWLEDGE TRANSMISSION AND TRAINING

##### Aims

The knowledge transmission and training theme is closely linked to the aging of the active labour force and the integration of new workers on the one hand, and on the other, to the growing need for flexibility in enterprises, which translates into greater versatility and internal mobility of workers, all against a backdrop of the accelerated transformation of the nature of work. Given that the risk of occupational injuries is higher during the first few weeks on a new job or when workers have to acclimatize to a new work environment or new tasks, this theme has been updated in this strategic research planning exercise for the SPWE field.

The aims of the work related to this theme are to study the organizational factors that support the development of versatility and acquisition of OHS competencies, and to foster the transmission of knowledge from experienced workers to new workers.

Particular attention is also paid to the integration of OHS aspects into the in-house training given in companies or in the vocational training network.

The proposed approach therefore focuses more on conditions conducive to knowledge transmission and OHS competency development in the workplace than on developing specific training content.

##### Progress report

Six studies have tackled this theme from perspectives relating to the formal systems for delivering trade-related training or for orienting and integrating new workers into

work collectives. They all examined issues related to the transmission, co-construction, and operationalization of acquired knowledge and its sustainability, i.e. to the conditions facilitating or hindering the knowledge and skill acquisition process and their maintenance over time. Based on the results of these studies, these conditions stem from the organizational context and resources (temporal and physical) available. The knowledge gained from these studies points to the various characteristics inherent to the concept of the learning organization, also an interesting concept when it comes to developing OHS competencies.

##### Developments anticipated during the cycle

By focusing on the OHS issues faced by managers, workers, trainers, teachers, and learners (issues that differ depending on the employment sectors and study programs), the work planned for this new cycle will look mainly at the organizational factors and resources facilitating development of OHS competencies in enterprises or in the vocational training network.

One future project will involve, among other things, the development of a model for transferring a trade-related training course that has an OHS component and that was developed in one enterprise, to other enterprises operating in the same activity sector. One project and other developments are also under way to better equip teachers to give OHS training to young people in the Work-Oriented Training Path (WOTP) program and thus help build a true prevention culture in the upcoming generation of workers.

### 2.1.4.4 THEMES TO BE DEVELOPED

#### 2.1.4.4.1 COHABITATION OF DIVERSE POPULATIONS IN THE WORKPLACE

By 2021, according to the forecast data of the Fédération des chambres de commerce du Québec, 83% of the labour force will be composed of individuals from generations X, Y, and Z, while baby boomers will account for only 17%. In addition, the proportion of immigrants in the labour force in Québec is on the rise, as is the participation rate of women. Faced with a need for flexibility in the labour force, workers with precarious job status (agency workers, workers on call-back lists, temporary workers) form an integral part of workplaces. Companies also have to deal with workers with varying health status: some in sustainable-job-retention situations, others on temporary

work assignments or gradually returning to work after a long absence, some with functional limitations, and others with chronic diseases.

Few studies have examined the OHS issues involved in this cohabitation. Some studies have shown, for example, that in teams comprising mainly new workers, the more experienced employees find themselves in self-intensified work situations, which can have impacts on their OHS. Often, this intensified work pace is due to situations where one or more team members are mobilized to perform related tasks (training new hires, for example) or to limit the errors made by less experienced co-workers.

Moreover, Québec's openness as a welcoming nation means the presence of new arrivals in the workplace, further underscoring this theme's relevance.

### **Aims**

The main aim of this theme is to improve understanding of the OHS issues associated with the dynamics of cohabitation and to identify the facilitators and resources needed to foster the sustainable prevention of occupational injuries in particular contexts.

#### **2.1.4.4.2 DIGITAL REVOLUTION (4.0): OPPORTUNITIES AND RISKS**

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The fourth industrial revolution will significantly change the labour market, the employment relationship, and interactions in workplaces. A number of jobs will in fact see their tasks totally transformed by these technological changes. Some will be automated, which could offer new opportunities for reducing work demands, or again, create new risks. According to the INRS (2016), robotization in the industrial sector and automation in the service sector could be the major issues in the evolution of production over the next 25 years.

### **Aims**

This theme is aimed at improving our understanding of how the digital revolution is changing work, as it could create opportunities for reducing work demands just as it could create new OHS risks. More specifically, by developing such knowledge, this theme seeks to assist workplaces in integrating new technologies.

Developments are under way to define projects concerning the OHS issues related to collaborative robots, in conjunction with the Physical and Mechanical Risk Prevention field. Some researchers in the field also have their eye on other projects (concerning exoskeletons).

#### **2.1.4.4.3 OHS ISSUES ARISING FROM THE GROWTH IN SERVICES**

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According to data from Statistics Canada's *Survey of Employment, Payrolls and Hours*, or SEPH (2015), the average annual growth rate of salaried employment has been on the rise in the services sector for around 15 years, particularly in healthcare and social assistance services and in educational services. The very nature of work in the services sector, which often includes physical, cognitive, and emotional demands, poses particular OHS challenges. Furthermore, in its multi-year plan (2017-2019), the CNESST identified the healthcare sector as priority. Also, stress- and violence-related injuries affect workers in the services sector more frequently. A number of studies have already been funded by the IRSST in these sectors and have yielded benefits, especially in violence prevention. Other growth sectors, such as the social economy and sharing economy companies, have been little studied to date in relation to OHS.

### **Aims**

The service-delivery situations in which workers find themselves in this sector vary, depending on the goals

of the relationship with the client, the duration of the service-provider/client relationship, the client's degree of dependence, and the space where the activity is carried out. Based on these characteristics, these situations can be classified in six categories: welcoming and orientation, remote service delivery, advice and support, mediation and social interventions, personal care and services, and sales and commercial interactions (Cerf and Falzon, 2005).

The aim of this theme is to document the OHS issues specific to the service sectors and to identify the resources and organizational factors fostering sustainable prevention, by prioritizing two types of service-delivery situations: mediation and social interventions; and personal care and services. Some workplaces offering these types of services are characterized by the remoteness of the decision-making centre. Efforts will be made to understand the potential effects of such remoteness on OHS. This theme will also include an "emerging subject" component, as special attention will be paid to OHS issues in the social economy and sharing economy sectors.

#### **2.1.4.4.4 DEVELOPMENT OF METHODS FOR EVALUATING EXPOSURE AND ASSESSING RISK**

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Under this theme, work will continue on the development of ambulatory methods for evaluating exposure, begun in the context of the 2013-2017 five-year plan. Technological

advances offer unique opportunities for developing new methods in this field.

## Aims

The work related to this theme consists, first, of developing methods for evaluating physical demands in order to measure worker exposure to MSD risks in the workplace.

Second, it consists of designing tools and that can be used to assess psychological risks and that take the worker's activity into account.

### 2.1.4.4.5 EVALUATION OF INTERVENTIONS IN THE WORKPLACE

Several studies conducted under the previous five-year plan point to the pertinence of examining methodological developments related to the evaluation of interventions in the workplace. For a number of years, evaluations using randomized controlled trials have dominated in this field, particularly with regard to MSD prevention. Some authors, such as Stufflebeam and Shinkfield (2007), describe the limitations of these types of evaluation, which they regard as too restrictive in terms of organizations' needs and as limiting the possibilities of improving interventions.

The evaluation of complex interventions, such as those implemented to prevent occupational injuries in the workplace, therefore poses methodological challenges.

#### Aims

The aim of this theme is to develop adapted methods and tools for evaluating complex interventions in the workplace, and thus produce knowledge on the implementation conditions, effects, and success factors likely to facilitate transfer to other workplaces and better implementation.

### 2.1.4.4.6 PREVENTION CULTURES AND OHS

For roughly the past 20 years, workplace actors have been dealing with the growing intensity and complexity of work, fewer hierarchical levels (horizontal organization), and the compounding of external constraints.

The 2014 knowledge review of OHS management models revealed heightened interest in research on this question, judging by the increased number of publications and reports by various organizations since 2009. This increase followed the adoption of the *Global Plan of Action on Workers' Health 2008-2017* by the World Health Organization (WHO) in 2007.

To date, many studies have reported characteristics of management-related variables that influence OHS.

While these data point to possible courses of action for improving OHS results, the literature provides few indications of the processes associated with the pertinent winning management practices. Several avenues thus still need to be explored and from various perspectives.

#### Aims

The aim of this theme is to improve understanding of the issues related to the changing OHS culture in workplaces and to the development of winning practices that support sustainable development in companies. Another priority aim is to support managers' OHS-related work activities, as this is key to determining the factors facilitating or hindering the implementation of preventive measures.

### 2.1.4.4.7 PREVENTION AND AGING

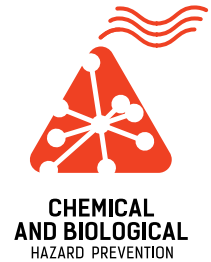
Due to the aging of the labour force and increased participation of workers aged 55 and over, the challenges posed by prevention throughout people's working lives are growing. What further differentiates the injuries sustained by workers aged 55 and over from those of all other workers are the occupational injury severity indicators. The average duration of compensation for older workers is nearly six weeks longer than for the labour force as a whole.

#### Aims

The anticipated developments related to this theme will involve documenting and improving understanding of the factors that facilitate the sustainable job retention of older workers before occupational injuries occur.



## 2.2 CHEMICAL AND BIOLOGICAL HAZARD PREVENTION



### CONTEXT

Every year, many Québec workers in a wide variety of work environments develop occupational diseases related to overexposure to chemical substances or biological agents. This situation could be prevented through better knowledge of the contaminants involved, worker exposure, and the related health risks.

### GOAL

The goal of the Chemical and Biological Hazard Prevention (CBHP) field is help prevent occupational diseases and adverse health effects, and to improve and maintain the health and well-being of workers exposed to chemical substances and biological agents. The preferred approaches are innovation, generating new knowledge, conducting critical assessments, and using existing knowledge.

Research efforts, often interdisciplinary in nature, focus on primary prevention and designing adapted tools for use in enterprises, particularly by aligning with the needs identified by the CNESST and its partners and by Québec workplaces. By extension, knowledge translation and information dissemination are also advocated.

### RESEARCH ORIENTATIONS

The activities conducted under the CBHP research field revolve around three main orientations:

1. Development of strategies and methods for assessing exposure and estimating health risks, using toxicological and epidemiological approaches, among others
2. Development and validation of technologies and tools designed to reduce and control exposure
3. Development of methods for sampling and analyzing chemical substances and biological agents

### 2.2.1 PUTTING THE FIELD'S PRIORITY ISSUES INTO PERSPECTIVE BASED ON STATISTICAL DATA

During the 2010-2012 period, chemical substances<sup>1</sup> were at the root of the 1,047 injuries accepted annually on average by the CNESST, of which 355 were attributable to occupational diseases. During the same period, biological

agents caused an annual average of 1,159 CNESST-accepted injuries, including 24 cases of occupational diseases (Table 1).

<sup>1</sup> The definition used includes (in addition to chemical products and compounds) rubber, tars, sealants, caulking materials, insulating materials, radiant metals, non-metallic minerals, smoke and combustion gases, as well as dusts and particles, subject to certain criteria pertaining to the nature and site of the injury.



**Table 1** Frequency and duration of CNESST-accepted industrial accidents and occupational diseases from 2010 to 2012 (annual average)

CAUSAL AGENT	INDUSTRIAL ACCIDENTS			OCCUPATIONAL DISEASES			TOTAL		
	Frequency		Average absence duration (days/case)	Frequency		Average duration (days/case)	Frequency		Average absence duration (days)
	#	%		#	%		#	%	
Chemical substance	692	0.8%	26	355	6.2%	136	1,047	1.1%	63
Biological agent	1,135	1.3%	7	24	0.4%	60	1,159	1.3%	8
CS <sup>1</sup> + BA <sup>2</sup>	1,827	2.1%	14	379	6.6%	131	2,206	2.4%	34
Other agent	84,841	97.9%	78	5,379	93.4%	41	90,220	97.6%	77
Total	86,668	100.0%	77	5,758	100.0%	47	92,426	100.0%	76

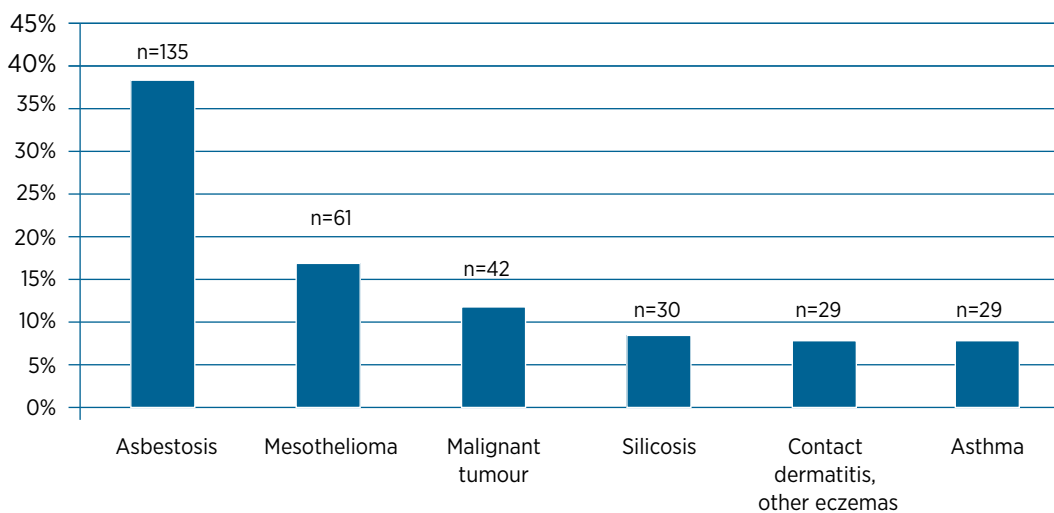
1. CS = chemical substance

2. BA = biological agent

Thus, of all the CNESST-accepted occupational diseases in the 2010-2012 period, 6.6% of the cases were caused by chemical substances or biological agents (6.2% and 0.4% respectively). Time-loss injuries (TLIs) were compensated for an average of 131 days per case, for a total of 49,649 days.

Moreover, six occupational diseases, including more than 25 cases accepted annually by the CNESST, were attributable to exposure to chemical substances. These illnesses included 92% of the cases related to chemical

substances (Figure 1). In decreasing order, they were (1) asbestosis (38% of the cases), (2) mesothelioma (17%), (3) malignant tumour (12%), (4) silicosis (8%), (5) contact dermatitis and other eczemas (8%), and (6) asthma (8%). The main causal agent of the illnesses was asbestos (65% of the cases), followed by silica (9%), unspecified or unclassified chemical products or compounds (5%), and cyanates (2%).



**Figure 1** CNESST-accepted occupational diseases caused by chemical substances, by nature of the disease, 2010-2012 (average annual frequency of more than 25 cases)

Also for the 2010-2012 period, an annual average of 130 fatalities compensated by the CNESST were attributable to occupational diseases caused by exposure to harmful substances. These deaths represented 100% of all fatalities due to occupational diseases in Québec. Of the 130, 82%

were related to asbestos, 9% to silica, and 9% to other substances not specified in the CNESST’s annual statistical reports. However, the types of diseases associated with these other substances are known: cancers, asthma, chronic obstructive pulmonary disease, other respiratory

diseases, and other occupational diseases that can be related to the CBHP field. It is worth noting that between 2000-2002 and 2010-2012, the average annual number of

CNESST-accepted deaths that were caused by accidents dropped from 103 to 79 cases, while the number of deaths caused by occupational diseases rose from 79 to 130.

## 2.2.2 PUTTING THE FIELD’S PRIORITY ISSUES INTO PERSPECTIVE BASED ON RESEARCH MAPPING AND SCIENTIFIC MONITORING AND SURVEILLANCE

A portrait of OHS research worldwide was produced in 2016. Mapping was done specifically for the Chemical and Biological Hazard Prevention field. It covered the 2011-2016 period and identified studies by consulting the Web sites of over 25 institutions and organizations dedicated to OHS. Each study identified was classified according to a hierarchical tree of keywords that yielded groupings by sector of activity concerned, aims of the study, methods used, contaminants examined, or corresponding CBHP research orientation.

In total, 292 studies conducted by nine institutes in five countries were documented. The breakdown is presented in Table 2. The most frequently cited sectors of research activity were manufacturing, followed by mining and agriculture, forestry, fishing, and hunting. A large number of studies also concerned the healthcare and social services sectors, and the waste management and remediation services sectors. Approximately one-quarter of the studies had an etiological purpose and were thus aimed at studying the causes of and factors in a disease, and at elucidating the toxicity mechanisms of various substances, be it through epidemiological studies or fundamental research. Exposure assessment was also a very common research objective, as was the development of laboratory methods and measurement tools.

The CBHP research themes most frequently cited in the abstracts of the studies documented were those of nanoparticles, carcinogens, and microorganisms. Most of the studies on nanoparticles involved the development of methods for assessing exposure, and fundamental studies aimed at determining their toxicity and health effects. Research work on carcinogens mainly involved epidemiological studies aimed at establishing associations between occupational exposures and the development of certain cancers. Microorganisms were targeted in studies aimed at assessing and reducing exposure, and at understanding contamination mechanisms in the health sector. Biological monitoring and risk assessment, as well as ototoxic substances, appear to be areas of growing research interest.

In addition to nanoparticles, which were the subject of more than 17% of the studies on chemical contaminants, the most frequently cited substances were solvents, hydrocarbons, pesticides, metals, and isocyanates. Regarding biological contaminants, mention is made mostly of the various moulds and bacteria associated with the waste management sector.

Lastly, approximately half of the documented studies fit into orientation I of the CBHP field, while the other half were divided evenly between orientations II and III. The studies and priorities of the CBHP field appear to converge with international trends, but some of the IRSST’s thematic programs fit into less documented niches. One such niche is the development of methods for detecting microorganisms or the modelling of exposure by means of statistical tools. The IRSST can aptly be regarded as a pioneer in these areas.

**Table 2** Number of studies on chemical and biological hazards for each research organization

ORGANIZATION	COUNTRY	NUMBER OF STUDIES
NIOSH	United States	95
IRSST	Canada	47
BAuA	Germany	45
INRS	France	30
ANSES	France	28
STAMI	Denmark	20
OCRC	Canada	19
IFA	Germany	5
WorkSafeBC	Canada	3

## 2.2.3 PUTTING THE FIELD’S PRIORITY ISSUES INTO PERSPECTIVE BASED ON NEEDS EXPRESSED BY PARTNERS

During the fall of 2016, the IRSST held several meetings with its partners to allow them to assess the work done in the context of the 2013-2017 plan and express their needs. Six sectors, or groupings of employment sectors, were targeted: (a) transportation, manufacturing, and industry, (b) mining, (c) agriculture, fishing, and green jobs, (d) construction, (e) healthcare, social services, and education, and (f) provincial and municipal administration. Appendix 1 provides a summary of the needs expressed regarding chemical and biological hazards, by employment sector.

As a whole, the identified needs are already accounted for in the CBHP’s thematic programs or research themes. However, to ensure an appropriate response to certain

specific needs, changes are proposed to the current research structure, including mainly the development of a thematic program on sensitizing and irritating agents that would incorporate the theme of occupational asthma and obstructive respiratory diseases. A thematic program on pesticides will also be developed to replace the theme of chemical and biological contaminants in agricultural environments. The advantage of such thematic programs is that they help provide a clear vision defined on the basis of general objectives. Each program is expected to include several studies or components aimed at developing evaluation research approaches that ensure goal attainment.

## 2.2.4 THEMATIC PROGRAMS

During the 2018-2022 five-year period, a number of changes and developments will be required to enable the CBHP field to take into account issues emerging at the international and national levels, but particularly at the provincial level, and to respond more effectively to the needs identified by partners. It is therefore proposed

that (1) the current thematic programs be maintained and some changes be made, as needed, and that (2) three new thematic programs be developed to replace four research themes. The essentials of these changes and developments are presented in tables 3 and 4.



**Table 3** Developments and changes anticipated for the 2018-2022 five-year period

CURRENT	PROPOSAL
<b>CURRENT THEMATIC PROGRAMS</b>	
Occupational carcinogens	Maintain
Chemical and biological hazards related to green jobs	Maintain
Respiratory protection	Maintain
Microorganisms in the workplace	Update, to highlight the presence of infectious agents in the workplace
Exposure science	Update, to make the concepts of multi-exposure and co-exposure more explicit
Ventilation and air quality	Redefine
Asbestos and other elongated mineral particles	Redefine under the name “Asbestos and other mineral particles”
<b>RESEARCH THEMES</b>	
Asthma and obstructive respiratory diseases in the workplace	Develop a thematic program under the name “Sensitizing and irritating agents”
Chemical and biological contaminants in agricultural environments	Develop a thematic program under the name “Pesticides”
Nanoparticles	Develop a thematic program under the name “Nanoparticles and ultrafine particles”
Silica	Integrate into the “Asbestos and other mineral particles” thematic program

**Table 4** Breakdown of thematic programs by the field’s research orientations

	ORIENTATION 1	ORIENTATION 2	ORIENTATION 3
<b>CURRENT THEMATIC PROGRAMS</b>			
Occupational carcinogens	X		
Chemical and biological hazards related to green jobs	X		X
Respiratory protection		X	X
<b>THEMATIC PROGRAMS TO BE UPDATED</b>			
Microorganisms in the workplace	X	X	X
Exposure science	X	X	X
<b>THEMATIC PROGRAMS TO BE REDEFINED</b>			
Ventilation and air quality		X	X
Asbestos and other elongated mineral particles	X		X
<b>THEMATIC PROGRAMS TO BE DEVELOPED</b>			
Sensitizing and irritating agents	To be determined		
Pesticides			
Nanoparticles and ultrafine particles			

## 2.2.4.1 CURRENT THEMATIC PROGRAMS

### 2.2.4.1.1 OCCUPATIONAL CARCINOGENS

#### Aims

The long-term aim of this thematic program is to help prevent hazards associated with occupational exposure to carcinogens. The priority orientations are to better characterize exposure to carcinogens, control exposure to diesel exhaust, and assess the carcinogenic hazards present in green jobs, while exploring methods that take account of multi-exposures. As this thematic program is relatively new, the specific objective of the five-year plan is to consolidate what has been learned and foster new knowledge along the same lines. It must be pointed out that the cross-cutting nature of this program means that it shares some common aims with other programs.

#### Progress report

The thematic program on occupational carcinogens was approved by the Institute's Scientific Advisory Board in March 2014. Since then, a research activity has been carried out to identify the industries and occupational groups in which Québec workers may be exposed to carcinogens. A review of the literature on cancer risks related to the job of firefighter, requested by the CNESST, is nearing completion. A third study that involves estimating the human and economic burden posed by occupational cancers in Canada has resulted from collaboration in a pan-Canadian project led by Ontario's Occupational Cancer Research Center. Lastly, a pilot study aimed at exploring the potential exposure of hygiene and sanitation workers

to antineoplastics was begun. The subsequent phase of the study on cancers in the aluminum smelting and refining sector was postponed due to the restructuring of the main enterprises concerned.

The cross-cutting nature of this program links it to other activities, research projects, and expertise services concerning carcinogens, particularly in the context of the thematic programs on asbestos, chemical hazards related to green jobs, exposure science, and respiratory protection. In addition, work done by the Laboratory Division has contributed to the development of an analytical method for measuring diesel motor exhaust emissions.

#### Developments anticipated during the cycle

The work begun during the 2013-2017 five-year cycle will continue with the aim of better characterizing worker exposure in certain industrial sectors where multi-exposure to carcinogens is customary and of exploring work practices and exposure control measures in workplaces. A meeting with partners concerned by four frequent carcinogens in the workplace and a scientific activity with researchers from various disciplines may steer the work in a more specific direction in order to respond more directly to the requests from the concerned workplaces. The merits of continuing the study in the aluminum smelting and refining sector by adding more 10 years of monitoring the diagnosed cancers (i.e. cases of cancer diagnosed in workers from 2005 to 2014) will also be explored.

### 2.2.4.1.2 CHEMICAL AND BIOLOGICAL HAZARDS ASSOCIATED WITH GREEN JOBS

#### Aims

In the current context of climate change, jobs generated by efforts to green the economy are fast proliferating. Government incentives for sustainable development have fuelled the marketing of new technologies and the creation of so-called green jobs in a number of sectors. Three of these sectors have been deemed priority: waste management, energy, and green substitute products. The thematic program developed during the 2013-2017 period laid the groundwork for research in these three sectors. The ultimate aim is to ensure that workers' occupational health and safety is safeguarded at all times, while factoring in efforts to reduce the environmental footprint of today's lifestyle.

#### Progress report

Even before developing the thematic program on preventing chemical and biological hazards related to

green jobs, several studies had been conducted on this theme under other themes or programs. Thus, on an ad hoc basis, the IRSST had supported a number of studies pertaining, in particular, to the photovoltaic industry, biological degreasing stations, solvent substitution, food



waste composting, and the bimethanation of putrescible organic material. A study entitled *Évaluation de l'exposition aux contaminants chimiques des travailleurs œuvrant dans le recyclage primaire des matières résiduelles électroniques au Québec et appréciation du risque sanitaire* [evaluation of chemical contaminant exposure among workers in the primary electronic-waste recycling sector and assessment of health risks] in Québec is the first to have resulted directly from the thematic program; it began in January 2017. This study will permit a scientific professional to conduct her doctoral research, thereby ensuring a new-generation researcher for the Institute in the field of toxicology. A second study, this time on green solvents, also began in early 2017.

### 2.2.4.1.3 RESPIRATORY PROTECTION

#### Aims

Inhalation is the most frequently documented and most heavily regulated route of exposure to chemical and biological contaminants. The aim of this thematic program is to improve the effectiveness of respiratory protection practices by looking into chemical resistance, protective factors, and constraints associated with wearing respiratory protective devices (RPDs).

#### Progress report

One of the main research projects involved optimizing the computer-based tool Saturisk. The database information on cartridges and solvents was updated. All the cartridges and carbons were characterized, and the service life of all the cartridges is now calculated using the same computation assumptions and the same industrial hygiene approach, thus providing a reliable resource to meet workplace needs. A research activity on the chemical resistance of acid-gas respiratory protection cartridges

#### Developments anticipated during the cycle

Given the relative newness of this thematic program (September 2015), the studies expected over the next five years will fit into the climate change context and involve the same three priority employment sectors: waste management, energy, and green substitute products. Particular attention will be paid to the exposure of workers to chemical substances in the photovoltaic cell manufacturing industry, and efforts will be made to assess and characterize the hazards associated with certain substitute products.

for sulphur dioxide has already begun. So too has a study aimed at characterizing the physical and physiological constraints associated with wearing a half-mask fitted with a P100 filter. In November 2016, a thematic program was also adopted as planned.

#### Developments anticipated during the cycle

The current research described above will be completed. The work on acid-gas cartridges may be extended in order to produce a first version of a service life calculator. The study on the effectiveness of N95 filtering facepiece respirators will continue, and will be expanded to include P100 respirators. The potential of activated carbon fibres as an alternative material to active charcoals and to filters in respirator cartridges may be evaluated. The characterization of RPDs designed to capture ultrafine and fine particles will be one of the developments during this new cycle. Lastly, it is anticipated that a method for measuring the protection factors afforded by selected RPDs in the field will be developed and tested.

## 2.2.4.2 THEMATIC PROGRAMS TO BE UPDATED

### 2.2.4.2.1 MICROORGANISMS IN THE WORKPLACE

#### Aims

This thematic program has three main aims: to develop state-of-the-art techniques for improving identification of microorganisms and their by-products; to diversify sampling strategies; and to evaluate the effects and early signs of effects on worker health. The updated program planned for the new five-year cycle should include, more specifically, problems related to pathogenic and infectious agents.

#### Progress report

One of the innovative dimensions introduced during the 2013-2017 period concerned the use of molecular biology tools. Generally speaking, the research involved assessing worker exposure (e.g. evaluating bioaerosols and gaseous compounds in agri-food and residential organic waste composting), developing analytical methods (e.g. developing a method for the molecular detection of bacteria of the genus *Legionella* in water samples from cooling towers and water heaters), developing control

methods (e.g. controlling exposure to bioaerosols during bronchoscopy operations), and assessing health effects (e.g. predicting bioaerosol immunogenicity using dendritic cells).

Two new studies began in 2017. The first is attempting to develop molecular markers for detecting the moulds used to determine the Environmental Relative Moldiness Index (or ERMI), ultimately to allow for assessment of the mycotoxin risk of indoor air in workplaces. The second involves evaluating embalmers' exposure to bioaerosols and assessing the risk to their health.

#### 2.2.4.2.2 EXPOSURE SCIENCE

##### Aims

The aims of this thematic program are to consolidate and advance knowledge pertaining to the characterization of occupational exposure by using approaches such as taking measurements in the workplace or modelling and estimating exposure for purposes of predictive and risk analysis. The studies concern sampling strategies, primarily with regard to inhalation and dermal exposure, as well as data interpretation (dusts in the ambient air, in the oronasal region, and on the epidermis; deposited dusts; exposure biomarkers), metrology, and making better use of existing data for epidemiological, monitoring, and surveillance purposes.

##### Progress report

The research work carried out or begun during the 2013–2017 period fit in with four major orientations: modelling and estimating exposure, sampling strategies and interpreting measurements, metrology, and making better use of data.

Studies began for the purpose of developing new methods for facilitating and improving the identification and characterization of exposure in the workplace (including studies on bitumen and solvent vapours). Some of the studies sought to document exposure in activity sectors of specific interest, such as the granite processing sector or swimming pool sector, and to identify the determinants of occupational exposure. Additional studies are anticipated to pinpoint the most promising mitigation and attenuation measures.

The development of new knowledge on sampling strategies and on the interpretation of measures of exposure to chemical agents in the air and in biological matrices remains a key component of the exposure science thematic program (e.g. updating of the *Guide de surveillance biologique de l'exposition* [guide to the biological monitoring of exposure]). Moreover, in view of

##### Developments anticipated during the cycle

In terms of methods, molecular biology techniques, which allow for clearer and faster identification and quantification, will continue to be used to document workplace exposure. Exploratory work will begin on the potential use of biomarkers to determine worker exposure to bioaerosols. Studies on the survival of viruses in the laboratory setting and in the field will be undertaken. The type of ventilation ideal for controlling biological contaminants will be modelled for certain workplaces. Lastly, the IRSST will continue to support efforts to create a research chair on bioaerosols and respiratory health.

the few existing practical tools, the transfer of methods and knowledge on exposure to support the practices of professionals in the workplace is still of the utmost importance.

Lastly, some research work enabled one of the IRSST's scientific professionals to undertake and complete doctoral studies, thus ensuring staff succession for the Institute in this field and maintaining its position as a centre of excellence, a position it has held for a number of years already. The aim of the research conducted was to characterize the exposure measurements collected by the U.S. federal agency OSHA to estimate occupational exposures in North America.

##### Developments anticipated during the cycle

The strategy for assessing chemical hazards has traditionally involved assessing worker exposure by means of *in situ* measurements and comparing them to norms, reference values, or permissible exposure limits. Such an approach demands considerable human, physical, and financial resources as it requires a large number of measurements and sound statistical analysis. While it remains the approach envisaged for assessing risks and orienting preventive actions, research efforts in the exposure science program during the 2018-2022 five-year cycle will focus more specifically on developing and proposing new approaches and methods for improving the identification and characterization of exposure in the workplace.

It is anticipated that the proposed research work will document exposure in various activity sectors of interest and identify the determinants of the occupational exposure, mainly through the use of empirical statistical models. The development of new methods of sampling and analysis for quantifying exposure to chemical agents in the air and in biological matrices remains a key component of this program. Dissemination of the recommended best practices for environmental and biological monitoring of

exposure to chemical agents is also required to better characterize worker exposure. Research activities are needed to develop new approaches that take multi-exposure into account and to identify activity sectors where multi-exposure and cumulative risks are particularly prevalent. Lastly, research work is still needed to make better use of existing data on occupational exposure to

chemical substances measured by professionals in the workplace, both in Québec and internationally, and to assess the objectives and limitations of occupational exposure measurement strategies.

Most of the anticipated developments will require an updating of the thematic program.

### 2.2.4.3 THEMATIC PROGRAMS TO BE REDEFINED

#### 2.2.4.3.1 VENTILATION AND AIR QUALITY

##### Aims

The aims of this thematic program are to develop and validate methods for assessing the effectiveness of systems designed to control exposure to chemical and biological contaminants, both through general and local exhaust ventilation systems and optimization of industrial processes. The program also studies filtration and the aerologic parameters of pollutant emission and dispersion.

##### Progress report

The research activities aimed at identifying appropriate ventilation techniques for preventing chemical and biological hazards in confined spaces (interfield research activity with MPRP) and exposure to nanoparticles and fine and ultrafine particles were completed. Also completed were the theoretical and experimental modelling activities aimed at assessing worker exposure to chemical or biological contaminants based on exposure determinants such as ventilation parameters and industrial process parameters. Moreover, in 2016, an agreement was signed

by the IRSST and Concordia University for joint use of a research platform on particle and gas filtration. Lastly, the work of characterizing the filters used in ventilation and industrial vacuum systems to capture ultrafine and fine particles is ongoing.

##### Developments anticipated during the cycle

The approach aimed at assessing safety concepts right from the design phase will be promoted in future work. Dust dispersion and control during processing operations (polishing, cutting, drilling, etc.) that involve natural or synthetic materials will be assessed in the laboratory and validated in the workplace using expertise acquired during the research work on granite polishing. Digital and experimental simulation methods will be developed as a means of estimating pollutant emissions or dispersion in the air and the performance of exposure control methods. Given the major changes that have taken place in the ventilation field in recent years, as well as projected and emerging needs, this thematic program will be redefined.

#### 2.2.4.3.2 ASBESTOS AND OTHER MINERAL PARTICLES

##### Aims

The aims of this thematic program fit mainly into the industrial hygiene component, with efforts focused on documenting, assessing, and monitoring exposure. In particular, this involves evaluating various work environments where mineral particles are present, taking respiratory protection and the effectiveness of containment measures into account.

##### Progress report

A research activity involving the development of a new approach for improved identification and quantification of asbestos fibres in the air and in bulk materials enabled one of the IRSST's scientific professionals to undertake and complete doctoral studies, again ensuring staff succession in this field. At the CNESST's request, six scientific expert

assessments were carried out in asbestos-containing zones and during excavation work under a highway interchange to assess the release of airborne asbestos fibres into the workers' breathing zone. A bibliographic search on the link between asbestos concentrations in the soil and air also shed light on the parameters that contribute to decreasing airborne fibre concentration. In addition, a roundtable meeting of international experts in the field of evaluating asbestos in soils was convened at the IRSST's request. The goal was to produce a reference document detailing the advantages and limitations of currently available methods of sampling asbestos-containing soils and of preparing and analyzing such samples. In addition, a transmission electron microscope (TEM) was purchased and installed at the Institute, making it easier to conduct analyses according to best practices. Lastly, time constraints prevented the project aimed at establishing reference



levels for asbestos fibres (announced in the previous five-year plan) from being carried out.

### **Developments anticipated during the cycle**

Activities aimed at providing a framework for sampling asbestos-containing soils and preparing and analyzing samples will continue, while the current study on fibrogens and carcinogens in gold and iron ore mines will be completed. Furthermore, given Québec's world leadership position in the field of artificial intelligence, this

type of technology could be used to increase the precision and reliability of analyses of TEM images. In addition, the TEM will be adapted in certain ways to facilitate the identification and characterization of the crystalline silica analyzed, in both workers' breathing zones and lung tissues. Activities could also be launched to optimize the preparation of samples and analysis of asbestos fibres in lung tissues. With the arrival of a new researcher and the purchase of the TEM, this thematic program will need to be redefined.

## **2.2.4.4 THEMATIC PROGRAMS TO BE DEVELOPED**

### **2.2.4.4.1 SENSITIZING AND IRRITATING AGENTS**

#### **Aims**

Occupational asthma and obstructive respiratory disease were one of the priority research themes in the 2013-2017 five-year plan. The aim of this theme was to identify the causal agents and work situations most often associated with the development of occupational asthma and obstructive diseases of the respiratory system.

#### **Progress report**

Activities involving the revision of the *Guide for the Safe Use of Isocyanates* and the development of a method for determining the concentration of crustacean proteins were carried out. In addition, a new study, proposed in 2017 under the title *Validation of the Work-related Asthma Screening Questionnaire – Long version (WRASQ(L))<sup>TM</sup>* to improve early detection, should begin soon. One of the issues targeted during the 2013-2017 five-year cycle was that of verifying the Institute's interest in supporting a thematic program on asthma and obstructive respiratory diseases.

#### **Developments anticipated during the cycle**

Based on consultations with our partners in the workplace and research communities, for the 2018-2022 period, we propose integrating the occupational asthma and obstructive respiratory diseases theme into a broader thematic program under the name "sensitizing and irritating agents." This will also make for better alignment of the IRSST's research activities with the recommendations made by several industrial hygiene associations, such as the American Conference of Governmental Industrial Hygienists.

The new program would have two components: one on sensitizing agents and respiratory irritants and the other on sensitizing agents and skin irritants. The first component (concerning respiratory problems) would thus respect the wish of both partners and researchers to retain the part on occupational asthma and obstructive respiratory diseases. And, by including a component on sensitizing agents and skin irritants in the new program, associated and doubtlessly related activities could address other workplace concerns, particularly by using an epidemiological approach. In fact, many Québec workers report work-related skin injuries, such as occupational dermatitis. With its inclusive nature, the new thematic program would adequately address these research needs.

#### 2.2.4.4.2 PESTICIDES<sup>2</sup>

##### Aims

The aims of the research theme on chemical and biological contaminants in agricultural environments (the precursor to the thematic program on pesticides proposed for development in this new five-year plan) were to identify the agricultural workers at greatest risk of exposure to chemical and biological contaminants, assess their exposure, and estimate the potential health risks they face. Pesticides are chemical substances still widely used in today's agri-food industry to ensure high production yields or quality products. Considering the quantities used, the potential health risk they pose to workers, and the needs expressed by partners, it was deemed necessary to develop a thematic program specifically on pesticides.

##### Progress report

The research activities carried out under this theme have essentially focused on the pesticides widely used in Québec. An exhaustive general review was conducted of the personal protective equipment used to reduce exposure to pesticides in farming and was contextualized for apple production. Possible avenues for reflection and improvement were proposed to promote better protection of apple producers. Toxicokinetic modelling tools were also designed to assess exposure to three pyrethroid pesticides by means of controlled studies on volunteers, and in the case of two pyrethroids, field studies on workers. The studies on volunteers produced new urinary and blood profiles of the metabolites of these pesticides that can be used to address certain uncertainties observed in a toxicokinetic model. They also provided a better understanding of the significance of contaminant measurements in accessible biological matrices such as urine. The toxicokinetic modelling performed proved useful for inferring the main routes of workers' exposure and for establishing the corresponding doses absorbed, based on adjustments made to the urinary profiles observed. The study on workers also showed the impact that tasks have on pyrethroid pesticide exposure, and highlighted the importance of evaluating the effects of co-exposure to several pesticides.



##### Developments anticipated during the cycle

As a continuation of already completed activities, the thematic program that will be developed as part of the 2018-2022 five-year plan will still focus on the pesticides most frequently used in Québec and posing the highest potential health risk. It will also seek to improve knowledge of occupational exposure to pesticides and to propose solutions for reducing this exposure. Determining pesticide exposure using biological measurement methods will be a priority orientation. All methods of controlling exposure (substitution-elimination, administrative and engineering measures, and personal protective equipment) could be studied. The projects associated with this thematic program could also be inter- and transdisciplinary in nature.

<sup>2</sup> In Québec, the *Pesticides Act* defines a "pesticide" as "any substance, matter or microorganism intended to directly or indirectly control, destroy, mitigate, attract or repel any organism that is injurious to or noxious or troublesome for humans, animal life, vegetation, crops or any other object, or intended for use as a plant growth regulator..."

### 2.2.4.4.3 NANOPARTICLES AND ULTRAFINE PARTICLES



#### Aims

In these days when a growing number of Québec companies are using nanotechnologies, it is becoming all the more important to support their development while also protecting workers' health and safety. The research theme on nanoparticles (NPs) was intended to facilitate the task of determining workers' exposure levels and the development of a variety of information and support tools, ultimately to assist establishments and workplaces that potentially expose Québec workers to nanoparticles in managing potential health risks.

#### Progress report

The activities conducted confirm that Québec workers are exposed to engineered nanoparticles and to ultrafine particles produced unintentionally in their workplaces. This is the case in various sectors of activity, including

the production of metallic or carbon nanoparticles and nanoclays, but also for secondary users such as those in the manufacturing and energy sectors. In addition, the research work resulted in the proposal of an innovative strategy allowing for more precise assessment of exposure to engineered nanomaterials, by combining techniques and methods involving a minimum of preanalytic handling. The strategy recommended for systematic evaluations of workplaces that produce and use such materials includes the use of direct-reading instruments, but also of specific sampling and analytic methods.

#### Developments anticipated during the cycle

Applications using nanomaterials are evolving at a frenetic pace, and the number of workers who will be exposed to NPs will increase at a similar rate, making it essential for the IRSST to maintain a strong research capability in the field of OHS and nanomaterials. Moreover, given its role as a WHO Collaborating Centre and its expert-status participation in Working Groups of the International Agency for Research on Cancer (IARC) on the carcinogenicity of fluoroadenine, silicon carbide fibres, and carbon nanotubes, it is an opportune time to develop a thematic program on both nanoparticles and ultrafine particles. This program will focus on metrics and the characterization of nanoparticles and ultrafine particles, as well as on analyzing their aerodynamic behaviour and studying means of controlling exposure.



## 2.2.5 APPENDIX 1 – SUMMARY OF NEEDS EXPRESSED BY PARTNERS REGARDING THE PREVENTION OF CHEMICAL AND BIOLOGICAL HAZARDS

### TRANSPORTATION, MANUFACTURING, AND INDUSTRY SECTORS

- Biological hazards faced by waste collectors involved in collecting compostable waste
- Probabilistic approach to exposure assessment
- Assessment of the combined effects of exposure to chemical substances and to medications, drugs, or alcohol
- Exposure of forestry workers to chemical mixtures during brush cutting operations
- Exposure to fine particles (plastics industry), diesel motor exhaust, and welding fumes

### MINING SECTOR

- Glove resistance to chemical products
- Improvement of direct-reading technologies for assessing silica and asbestos exposure
- Assessment of the efficiency of filters for biofuel engine emissions

### AGRICULTURE, FISHING, AND GREEN JOBS SECTORS

- Development of a guide for protecting farmers against pesticides
- Exposure to dusts and pesticides used in treated seeds
- Exposure to pesticides during ornamental crop cultivation, preparation of pesticide solutions, and extermination work
- Exposure in recyclable-waste sorting plants
- Exposure during industrial cleaning

### CONSTRUCTION SECTOR

- Ongoing testing for worker exposure to asbestos in soils
- Exposure to hazardous products during asphalt scarification
- Exposure to lead on work sites and during removal operations
- Exposure to welding fumes
- Exposure to synthetic glass fibres used in insulation
- Hazards associated with mould decontamination involving CO<sub>2</sub> methods

### HEALTHCARE, SOCIAL SERVICES, AND EDUCATION SECTORS

- Problem of hazardous medications such as antineoplastics
- Cancers in pathology laboratories
- Hazards resulting from exposure to chemical products in the autopsy and dissection sectors

### **PROVINCIAL AND MUNICIPAL ADMINISTRATION SECTOR**

- Air quality in buildings
- Health problems related to the use of warm asphalt
- Problem associated with new exotic diseases, particularly in abattoirs
- Exposure to chloramines in swimming pools
- Hazards associated with “green” cleaning products

## 2.3 MECHANICAL AND PHYSICAL RISK PREVENTION



### CONTEXT

Every year, many workers are involved in accidents (some serious or even fatal) or contract occupational diseases caused by their exposure to the multiple hazards posed by the machines with which they come into contact and their work environment. Preventive actions can be taken at the source, on the work environment itself, and with workers directly to eliminate the risks, or, when measures cannot be implemented to eliminate or reduce risks at the source, by having workers use personal protective equipment (PPE). The priority OHS, scientific, and technological issues studied in this field concern the machine-related risks; noise and vibrations; physiological constraints; excavation work; falls from heights, on the same level, or due to slipping; and mechanical risks.

### GOAL

The research work in this field involves developing methodological, metrological, and simulation tools, as well as testing and evaluation methods to help those responsible in the workplace diagnose problems and assess

risks more effectively. It also focuses on creating support tools for selecting, improving, and designing preventive solutions (risk reduction at the source, collective and personal protective equipment), taking the human factor into account.

### RESEARCH ORIENTATIONS

The activities conducted under the MPRP research field revolve around three main orientations:

1. Assessment of the mechanical and physical risks generated by machines or the work environment
2. Reduction of mechanical and physical risks
3. Taking the human factor into account in the evaluation and control of mechanical and physical risks

These orientations allow us to cover the problems relating to the many risks recurrently evidenced in compensation statistics, research mapping, and our partners' needs.

### 2.3.1 PUTTING THE FIELD'S PRIORITY ISSUES INTO PERSPECTIVE BASED ON STATISTICAL DATA

Examination of the five-year indicators produced by the IRSST's Statistical Knowledge and Surveillance Group reveals that the decline in the number of occupational injuries that began in the early 1990s has continued over the past few years. It translates into a 23% drop in the number of occupational injuries accepted for the 2010-2012 period compared to that for 2005-2007.

For 2010-2012, over 92,400 occupational injuries were accepted annually, with nearly 75% resulting in compensated lost time. Occupational injuries associated with mechanical or physical risks represent an appreciable proportion of all CNESST-accepted injuries, accounting for 57% of cases during the 2010-2012 period. Compensated time-loss injuries (TLIs) associated with problems covered

under the MPRP field accounted for 54% of the cases during that period.

The two predominant risks for the MPRP field (each representing 21% of the accepted injuries) are (1) falls on the same level and slips/trips with no falls, and (2) the mechanical risks associated with machines, tools, or vehicles, including road accidents (mechanical risks-MTV). These risks rank among the five biggest risks associated with the MPRP field in terms of the total costs resulting from accepted occupational injuries. Injuries caused by falls on the same level and slips/trips with no falls affected all activity sectors and generated total costs<sup>1</sup> (\$435 million) that put them in fourth place for costs. They experienced the lowest decline (14%) in number of compensated TLIs relative to the 2005-2007 period. Mechanical risks-MTV ranked second in terms of total costs (\$643 million), but experienced a significant drop of 30% in the number of accepted occupational injuries. It should be noted that the total costs associated with the risks studied under the MPRP field represented 64% of all costs for CNESST-accepted occupational injuries.

After falls on the same level, slips/trips with no falls, and mechanical risks-MTV (which together caused the largest number of accidents during the 2010-2012 period) come three other risks with a similar occupational injury frequency: falls from heights and jumps to a lower level (9%), fixed production machinery (7.5%), and noise and hearing loss (9%). However, these risks differ in how they evolved compared to the 2005-2007 period. While a 36% drop was seen in fixed production machinery-related injuries accepted or with compensated time loss in 2010-2012, those related to falls from heights and jumps to a lower level dropped by 17%. The noise and hearing loss problem is the only one for which the number of accepted occupational injuries increased (up by 62%). This increase translated into the highest total costs (\$865 million)

compared to the costs of the other MPRP-related problems, and constituted an 81% increase over the 2005-2007 period. Looking at cost per injury, noise-induced hearing loss still ranked first, at over \$191,000 per injury. Moreover, accepted occupational injuries associated with noise and hearing loss generated a permanent physical or mental impairment (PPMI) in 75% of the cases documented for the 2010-2012 period (compared to a proportion of only 17% for all injuries).

Accounting for roughly 1% of all accepted occupational injuries related to the MPRP field, injuries caused by vibrations fell mainly into two categories: whole-body vibrations and hand-arm vibrations. The latter were associated with an average compensation duration of 179 days per injury, and with the highest increase in average cost per injury (56%) of all the problems studied in this research field.

Lastly, of the 92,400 occupational injuries accepted annually by the CNESST during the 2010-2012 period, 172 resulted in the death of a worker<sup>2</sup>. The data indicate that 75 of these fatalities (43%) were attributable to risks studied in the MPRP field, representing an 18% drop from the 2005-2007 period. This drop in number of fatalities was bigger than that observed for all deaths (-3%). The largest number of fatalities associated with the MPRP field involved mechanical risks-MTV, with 41 deaths, half of them resulting from a road accident<sup>3</sup>. The average annual number of deaths recorded in connection with all mechanical risks-MTV dropped by 30% compared to the 2005-2007 period. The two other MPRP-related risks responsible for a high average annual number of deaths pertained to falls from heights and jumps to a lower level (13 deaths) and fixed production machinery (10 deaths). The average annual number of deaths for these risks varied by +8% and -20% respectively compared to the earlier period.

## 2.3.2 PUTTING THE FIELD'S PRIORITY ISSUES INTO PERSPECTIVE BASED ON RESEARCH MAPPING AND SCIENTIFIC MONITORING AND SURVEILLANCE

To put the issues examined under the MPRP field into perspective, a portrait of studies conducted around the

world during the 2011-2016 period was produced for the various risks covered by this research field. Most of the

<sup>1</sup> Total costs include social costs (e.g. income taxes not collected), loss of productivity, and the human cost, in addition to CNESST payouts.

<sup>2</sup> Information observed on average 36 months after the injury deemed to have caused the worker's death.

<sup>3</sup> Road accidents have not yet been the subject of research activities in the MPRP field, but have been examined within a specific thematic program in the SPWE field.

research projects documented came from six organizations: the National Institute for Occupational Safety and Health (NIOSH) in the United States, the Institut national de recherche et de sécurité (INRS) in France, the Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA) in Germany, WorkSafeBC (WSBC) in British Columbia, the Federal Institute for Occupational Safety and Health (BAuA) in Germany, and the IRSST. A total of 276 MPRP-related projects were documented, including 140 (approximately 50%) conducted by NIOSH. A large number of these studies concerned the mining sector, in which NIOSH and American mining-related institutes have been actively conducting research for more than 100 years. The German institute IFA produced 20% of the studies, followed by the IRSST with 12%, and then the BAuA and INRS, each with 9%.

The mapping of MPRP-related studies for the 2011-2016 period showed that 62% of them concerned mechanical risks associated with machines, while 27% concerned physical risks that included noise, vibrations, and physiological constraints. Lastly, just over 4% of the studies involved falls and slips, falls from heights, and mechanical risks associated with hand power tools or objects (cuts, needles punctures). The remainder of the studies did not pertain to specific risks, but rather to more general aspects such as management or standardization.

The mapping exercise looked at research done on machine-related risks by identifying studies on the various types of equipment used in the workplace and on safety devices installed on machinery, as well as at risk factors associated with machines and their work environment. The scientific projects pertaining to machine-related risks often touched on more than one research theme (e.g. safety devices and equipment), making it difficult to associate them with a single theme. Our analysis of the international research was therefore qualitative in nature. Regarding the types of equipment used in the workplace, a great many studies were conducted on vehicles and robots, half of them on collaborative robots, known as cobots (robots sharing a work space with a worker), and a few on mobile robots. The number of studies on vehicles was also divided equally among the various risks associated with the vehicles theme and looked primarily at the traffic-accident risks posed by trucks, lift trucks (IRSST only), vehicle tipovers (protective structure for tractors), collisions between mobile machinery and pedestrians (IFA only), and rescue vehicles for mines (NIOSH only). These were followed by fixed machinery (servomotor press, machine-tools), for which most of the projects were carried out by IFA. With regard to safety devices on machines, half of the studies focused mainly on the reliability of safety-related parts of control systems. The other frequently researched aspect concerned presence detection (non-contact devices) and vision-based detectors. Other risks examined included

communication systems (nearly exclusively NIOSH for the underground mines sector), the instability of mine walls, support in mining galleries, and rock bursts (mainly NIOSH and, to a lesser extent, the IRSST, which is also conducting research on these subjects). Lastly, a few studies on thermal environments and electrical risks were documented. The mechanical risks caused by hand power tools or objects and potentially resulting in injuries such as cuts or punctures were examined in studies on protective clothing for hands and arms (three studies identified). One problem that had not appeared in previous mapping exercises was identified in three studies (IFA, INRS, and IRSST). This was the service life of equipment used to protect against falls from heights and exposed to variable environmental conditions such as rain and UV radiation. It should be pointed out that one of these studies (IFA) had an “emerging” research dimension to it in that it approached PPE from the angle of the integration of “smart” technological solutions (sensors, RFID-type emitters) to ensure monitoring over time. Lastly, to finish up with MPRP-related mechanical risks, the mapping exercise identified four studies on falls and slips, and four on falls from heights. The IRSST conducted a study on each of these subjects under these two thematic programs.

The documented studies dealing with physical risks accounted for 27% of all the scientific work identified: 16% pertained to noise, 9% to vibrations, and 2% to physiological constraints (thermal environment). Half of the studies on noise concerned risk assessment and worker exposure (noise emission and *in situ* measurements). Noise reduction (reduction at the source, design of machines and work premises, acoustic materials, etc.) and personal and collective protective equipment are priority research themes with regard to reducing noise pollution. Slightly over half of the vibration studies focused on whole-body vibrations, and more specifically, on the driving of vehicles, as well as on the related health effects and risk factors. The remainder of the scientific activities concerned hand-arm vibrations, and examined health effects and risk factors, above all. The NIOSH activities on physiological constraints concerned the productivity of agricultural workers exposed to heat-related risks, while the IRSST’s activities focused on the thermophysiological stress associated with the wearing of firefighter clothing and the use of thermal indices in the Québec context. As for aspects involving protective clothing, the scientific monitoring exercise raised the question of the impact of smart PPE technologies in the work world. This technological evolution potentially implies gains at the level of performance, comfort, and monitoring, and must therefore be taken into account in the reflection process on the overall evaluation of PPE.

In the past few years, some studies have assessed the potential effect of technologies on OHS with regard to

machinery and mines. Aspects related to telerobotic systems, presence detection, driving aids, process automation, and virtual and augmented reality systems have been examined. For the new five-year cycle, there are plans to document the effects of the technological developments

of Industry 4.0 on OHS, by means of a knowledge review. The outcomes of this process and of consultations with workplace representatives will determine the relevance of a thematic program on the subject.

### 2.3.3 PUTTING THE FIELD'S PRIORITY ISSUES INTO PERSPECTIVE BASED ON NEEDS EXPRESSED BY PARTNERS

In its 2017-2019 strategic plan, the CNESST prioritized three risks for which prevention efforts should be optimized: (i) slips and falls, (ii) noise, and (iii) controlling hazardous energy (in connection with lockout procedures). The research work in the MPRP field pertains specifically to these risks, particularly through the current thematic programs. Moreover, consultations with IRSST partners from four activity sectors (agriculture, fishing, and green jobs; mining; transportation, manufacturing, and industry; and construction) concerned by the risks studied in this field led to several findings. These findings have to do with research needs, the transfer of research-derived knowledge to workplaces, and the benefits in terms of standardization to which IRSST-funded studies contributed.

The following research needs are integrated into the field's research orientations and particularly stand out:

- Support tools for selecting the least harmful hand power tools and machines or the best adapted protective equipment for the risks associated with noise and hand-arm or whole-body vibrations
- Diagnostic tools adapted to industrial hygiene on construction sites, particularly as regards exposure to noise
- Comprehensive assessment of protective equipment, taking into account the human factor, the aging

of protective equipment, and the fact that several protective items may be used simultaneously

- Integration of safety into the design of machines and work spaces
- Machine safety in the particular context of small enterprises
- Non-compliance with lockout and hazardous-energy control procedures for mobile equipment
- Risks related to Industry 4.0, including the vulnerability of industrial facilities in terms of data security, collaborative robots, automation, configurable machines, artificial intelligence, and condition-based maintenance

The needs cited by partners generally align with the research work conducted in the IRSST's MPRP field, whether within or outside the existing thematic programs. However, certain problems, such as the integration of safety during the machine design phase, the safety of mobile equipment, and smart protective equipment, may become the subjects of new thematic programs. Thought will be given to these issues during the 2018-2022 cycle to evaluate any relevant opportunities.

## 2.3.4 THEMATIC PROGRAMS

Table 1 summarizes the current situation regarding the thematic programs in this field, as well as the proposed developments or changes in the new five-year cycle.

Table 2 shows the research orientations under which each of the thematic programs falls.

**Table 1** Developments and changes anticipated for the 2018-2022 five-year period

	PROPOSAL
Assessment of machine-related risks	Maintain
Lockout	Maintain
Hand power tools	Maintain
Acoustic barriers and materials for noise control	Maintain
Evaluation and modelling of hearing protection devices	Maintain
Shoring and shielding systems	Maintain
Resistance of protective gloves and clothing to mechanical and physical stressors	Complete “gloves” component and redefine “clothing” component
Protection against falls from heights	Update program to focus more on PPE
Prevention of slips and falls in outdoor work environments	Maintain
Audible alarm signals in the workplace	Maintain
Implementation and safe use of collaborative robots	Maintain
Alternative methods to lockout	Under development
Evaluation and selection of suspension seats	Under development
Safety of mobile equipment	Develop
Smart protective equipment	Develop or incorporate into the existing program on glove resistance and protective clothing

**Table 2** Breakdown of thematic programs by the field’s research orientations

	ORIENTATION 1	ORIENTATION 2	ORIENTATION 3
<b>CURRENT THEMATIC PROGRAMS</b>			
Assessment of machine-related risks	x		
Lockout		x	x
Hand power tools	x	x	x
Acoustic barriers and materials for noise control		x	
Evaluation and modelling of hearing protection devices		x	x
Shoring and shielding systems		x	
Prevention of slips and falls in outdoor work environments	x	x	x
Audible alarm signals in the workplace		x	x
Implementation and safe use of collaborative robots	x	x	x



THEMATIC PROGRAM TO BE UPDATED			
Protection against falls from heights		x	x
THEMATIC PROGRAM TO BE REDEFINED			
Resistance of protective gloves and clothing to mechanical and physical stressors		x	x
THEMATIC PROGRAMS UNDER DEVELOPMENT			
Alternative methods to lockout		x	x
Evaluation and selection of suspension seats		x	x
THEMATIC PROGRAMS TO BE DEVELOPED			
Safety of mobile equipment		To be determined	
Smart protective equipment			

The following section presents the (a) current thematic programs; (b) thematic programs under development; and (c) thematic programs to be developed. It is proposed that the 11 thematic programs already active in the 2013-2017

five-year cycle be continued; five of these will be completed and one will be redefined. Two thematic programs under development will begin, and the relevance of presenting two new programs will be assessed during this new cycle.

### 2.3.4.1 CURRENT THEMATIC PROGRAMS

#### 2.3.4.1.1 ASSESSMENT OF MACHINE RELATED-RISKS

##### Aim

The aim of this program is to conduct studies that will provide enterprises with robust, reliable tools for assessing (analyzing and evaluating) machine-related risks, which is a vital prerequisite to identifying appropriate means of reducing the risks.

##### Progress report

The 2013-2017 five-year plan anticipated the completion of a study involving practical experimentation with risk estimation tools applicable to industrial machine safety. The study was conducted with 25 subjects, using concrete scenarios of hazardous situations involving machines. It confirmed the impact of flaws and biases in the parameter configuration process and in risk estimation tools (flaws and biases that had been identified in a previous study of a more theoretical nature). Working in collaboration with researchers at the Health and Safety Laboratory (HSL) in the United Kingdom, the Québec researchers (UQTR, Polytechnique Montréal, and IRSST) were able to establish criteria for the construction of robust and reliable risk estimation tools. A research activity that involves comparing the content of several “machine risk assessment” training programs was also announced and should begin soon. In addition, a project involving analysis of the risks associated with interventions and work in confined spaces was added



to the initial research program. It led to the creation of a tool for analyzing the specific risks associated with this type of activity, thus allowing interventions in this type of space to be categorized. A knowledge transfer activity aimed at developing a risk analysis computer-based tool for confined space interventions was also begun. This program is 75% complete.

##### Developments anticipated during the cycle

It is expected that this program will be completed during the new five-year cycle. The research activity comparing the content of several “machine risk assessment”



training programs will be carried out. It should yield recommendations regarding content and pedagogical approaches for such programs, while drawing on the results of the previous studies. This study may lead to a knowledge transfer activity, which would wind up the

program. Upon completion, the program will have yielded robust and reliable configurations for risk estimation tools, as well as criteria for evaluating existing tools or developing new ones.

#### 2.3.4.1.2 LOCKOUT

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##### **Aims**

The aims of this program are to gain insight into the problems related to equipment lockout, to study the components of a lockout program and the conditions conducive to its application, to assess its application in workplaces, and to determine alternative solutions when lockout cannot be applied.

##### **Progress report**

The 2013-2017 five-year plan foresaw the finalization of a study (carried out at the CNESST's request) on the safety of interventions performed on machines operating at reduced speed or reduced energy levels. This study was in fact completed. It yielded a knowledge review and recommendations derived from the literature on reduced-energy modes of operation, particularly in terms of values for reduced speed, force, kinetic energy, contact pressure, and temperature. These recommendations will be useful for the purpose of designing alternative methods to lockout that incorporate notions of reduced speed or energy. A knowledge transfer activity aimed at producing a detailed technical fact sheet, including references and information on pertinent regulations, has been initiated. A second study involving observation and analysis of the application of lockout procedures in workplaces has also begun. Its goal is to take stock of machine lockout practices in different activity sectors. Aspects identified as problematic during previous research work are now the specific focus of study (e.g. verification of the procedure, short activities, unjamming, repairs requiring power to be on, sub-

contracting, and audits). The aim is to understand how enterprises and organizations cope with these difficulties, to identify the solutions implemented (e.g. alternative solutions to lockout), and to design a tool for auditing the application of lockout. Lastly, a study was carried out on mobile equipment in the municipal sector (e.g. dump trucks, tractors, loaders, and snow ploughs) to address the sector's needs. It involved monitoring, assessing, and revising a lockout implementation procedure. The five-year plan also anticipated the possibility of conducting other studies, in particular, of documenting alternative methods to lockout when it cannot be applied and of developing criteria and tools for selecting appropriate methods. These studies were not feasible during the last cycle. This program is 75% complete.

##### **Developments anticipated during the cycle**

During the new five-year cycle, the study on the application of lockout procedures in the workplace will be completed, and a final study on lockout in the construction sector will wind up this thematic program. The alternative methods to lockout that were briefly investigated during the 2013-2017 cycle will be the subject of a new thematic program under the name "Alternative methods to lockout." Since its launch, this program has made it possible to document and analyze lockout programs in enterprises, study the lockout procedures used in the municipal sector, and develop a tool for observing and monitoring lockout procedures.

#### 2.3.4.1.3 HAND POWER TOOLS

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##### **Aims**

The work carried out under this cross-cutting research program, which concerns both noise and vibration, is aimed at developing knowledge on the acoustic and vibratory performances of hand power tools, proposing ways to reduce their vibration and noise levels, and disseminating this information so that tool models with lower impact levels can be identified. More specifically, this involves identifying the mechanisms whereby tools generate noise and vibrations in work situations, evaluating their performance on laboratory test benches

that simulate working conditions, and clarifying dose-effect relationships for hand-arm vibrations.

##### **Progress report**

Begun some ten years ago, studies conducted under this program have improved knowledge of the mechanisms whereby tools generate noise and transmit vibrations in work situations, such as the hand power tools in automobile repair shops and mining equipment. During

the 2013-2017 cycle, other studies were also conducted to achieve all the aims of this thematic program. A first study enhanced knowledge of hypothenar hammer syndrome in workers exposed to vibrating tools. It showed that recommendations and possible courses of preventive action can be formulated for workplaces despite the difficulty of isolating vibrations from other risk factors. A second study led to the design and validation of a low-cost system for measuring the coupling forces exerted between a user's hand and the handle of a vibrating power tool. The sensors used in this measurement system can provide good estimates of the forces exerted by the user's hand on the tool in a context that simulates conditions found in the field. A third study, which evaluated the biomechanical parameters that can affect the transmission of vibrations as well as the muscle load placed on the hand-arm system, found that a stronger gripping force resulted in increased transmission of vibrations, and that the combination of high-amplitude and low-frequency vibrations placed the heaviest muscle constraints on the upper limbs. One last study led to the development of test benches specifically for hand-held pneumatic nail guns and representative of their use in the workplace. Experimental methods for measuring the vibration and noise emissions of this type of tool were also proposed, and recommendations made regarding possible ways to reduce them. Finally,

two exploratory activities focused more on modelling the vibration and impulse noise phenomena produced by hand power tools. A review of the literature on the potential of time-domain methods for modelling vibrations and the noise propagation of a simplified structure excited by a jolt, and an activity evaluating commercial software that uses this type of method, were thus carried out.

#### **Developments anticipated during the cycle**

During the 2018-2022 five-year cycle, a study will be proposed on hand-held pneumatic nail guns for the purpose of optimizing the existing test bench and simplifying the procedure for measuring vibration and noise emissions from these tools. Next, the vibration and noise generated by the different nail gun models offered on the market will be systematically measured on the optimized test bench, possibly leading to the production of a guide for selecting the least noisy and least vibration-producing hand nail guns. This approach to characterizing the noise and vibration emissions of hand power tools could eventually be extended to other activity sectors that also use impact tools. This study will wind up this thematic program. Future activities potentially related to hand power tools may be carried out on an ad hoc basis, depending on the needs expressed by workplaces.

### **2.3.4.1.4 ACOUSTIC BARRIERS AND MATERIALS FOR NOISE CONTROL**

#### **Aims**

The aim of this thematic program is to develop reliable, user-friendly, transferable methods and tools that workplaces can adopt and apply to help reduce worker exposure to noise. This can be achieved by developing support tools for designing noise-reduction solutions (for example, machine enclosures) and for evaluating the acoustic performance of materials, and by evaluating, or even creating, new noise-reduction technologies involving the use of acoustic barriers and innovative materials.

#### **Progress report**

Since this program began, tools have been designed for calculating the acoustic dispersion of structures and for predictively calculating the acoustic performances of machine enclosures. During the 2013-2017 cycle, it had been planned to refine and promote a support tool for designing machine enclosures, but given the limited number of potential users in Québec, it was decided not to pursue this course of action. Unfortunately, the steps taken toward creating an “industrial chair on acoustic ecodeign” with a view to developing new acoustic materials notably to control noise in the workplace (steps spearheaded by the Université de Sherbrooke and that could have involved the IRSST) did not bear fruit.

During the 2013-2017 cycle, the ICAR laboratory (Infrastructure Commune en Acoustique pour la Recherche ETS-IRSST, a shared infrastructure for acoustics research) inaugurated in 2011 was outfitted with experimental devices for characterizing the acoustic and mechanical properties of absorbent materials. This new characterization laboratory is invaluable because it can provide input parameters for tools designed to model performances of barriers and acoustic materials. It is also used in the context of another thematic program currently under way on personal hearing protectors.

During the same cycle, some research efforts were focused on designing a tool for better evaluating the acoustic absorption capacity of materials used to control noise. Currently, the characterization of the absorbent power of these materials is carried out only in the laboratory and lacks precision on several counts. Also, to date, no reliable technique exists for evaluating acoustic absorption *in situ* under the real conditions where these materials are used. This limits the level of reliability of the predictive calculations as well as the possibility of optimizing these techniques in the field. A study aimed at developing an innovative, robust, and reliable method for characterizing absorbent acoustic materials in both the laboratory and the field was carried out so that their real performances can be

evaluated once they are installed. This work will ultimately lead to better selection of materials for controlling and preventing noise in the workplace, whether in terms of cost or efficiency. This program is now 75% complete.

#### **Developments anticipated during the cycle**

For the new five-year cycle, there are plans to put the results of the previous study to good use by designing

an optimized probe prototype for measuring acoustic absorption in both the laboratory and the workplace. Given the limited number of collaborators and of proposals received on the subject, as well as the small number of users concerned by this research problem, it is difficult to sustain the program. It will therefore be terminated once the aforementioned study has been completed.

### **2.3.4.1.5 EVALUATION AND MODELLING OF HEARING PROTECTION DEVICES**

#### **Aims**

The aims of this program are to explore and develop methods for evaluating the real protection provided by hearing protectors in workplaces and to create support tools for designing effective and more comfortable hearing protectors (personalized protection).

#### **Progress report**

During the 2013-2017 five-year cycle, a study was carried out to develop tools and methods for better evaluating and improving workers' personalized hearing protection. Efforts were focused on developing innovative measurement methods and modelling tools for determining the sound pressure exerted on the eardrum of an ear that is protected by earplugs or an earmuff. Significant breakthroughs were also made in terms of understanding the acoustic behaviour of a protected ear excited through airborne vibrations or bone structure paths, with a view to developing optimal methods for measuring attenuation and occlusion effects and support tools for designing hearing protectors. The measurement prototypes developed were used on several occasions to help workplaces determine the real exposure of workers wearing hearing protectors. Some manufacturers showed interest in using the modelling tools to help them in their design efforts. The results of this study shed light on a number of prospects, including the potential of a method for measuring the occlusion effect based on vocal effort, the improvement of modelling tools through better geometric representation of the outer ear and the surrounding biological tissues, better knowledge of the properties of these tissues, and a validation of the related models. An activity that consists of enhancing the aforementioned method for measuring the occlusion effect was therefore initiated. The postdoctoral internship of an IRSST fellowship recipient and a research activity aimed at improving the aforementioned modelling tools also began. This work is based on a three-dimensional geometric reconstruction of the ear from individual MRI images obtained *in vivo* for the purpose of designing artificial ears better adapted to the study of hearing protection. It involves factoring in the geometry and

surrounding tissues of the auditory canal. Two activities focused more on modelling the behaviour of earmuffs excited into vibration by impulse noises. More specifically, a review of the literature on the potential of time-based methods for modelling acoustic transmission phenomena through earmuff-type hearing protectors, as well as an activity aimed at evaluating commercial software using this type of exploratory method, were carried out. During the 2013-2017 cycle, the ICAR laboratory acquired an audiometric test booth. This experimental infrastructure is vital to conducting hearing tests on human subjects, with and without protectors, in the context of the IRSST program, which is now deemed 75% complete.

#### **Developments anticipated during the cycle**

The work carried out since the start of this thematic program has concentrated mainly on improving methods for measuring physical indicators of the acoustic attenuation provided by hearing protectors in the field and in the laboratory, and on developing simulation tools for predicting these physical indicators. It has also involved measuring and predicting the occlusion effect produced by hearing protectors, which is associated with acoustic discomfort. However, much more progress is still needed in order for the aforementioned work to pass impacts on to workers (via manufacturers) and to preventionists and OHS managers in enterprises. This work will have to take into account overall comfort during evaluation of the effectiveness of hearing protectors and during the design process. In fact, the effectiveness of a hearing protector depends partly on the degree of attenuation it brings, which translates into an acoustic attenuation index measured in the laboratory. Its effectiveness also depends on the comfort provided by the protector. If it is uncomfortable, the worker may be inclined (1) to insert it incorrectly (not firmly enough) or (2) to wear it sporadically. Yet wearing protectors for insufficient time has major consequences in terms of effective protection of the individuals exposed. It is therefore important to be able to assess the comfort associated with hearing protectors and to design devices that offer both protection and comfort. In particular, linking

comfort to the design parameters of hearing protectors would assist manufacturers in this process.

The research work under this thematic program will continue in the new five-year cycle in order to improve the measurement and prediction of acoustic attenuation and the occlusion effect. Specifically, the study on the design of a new generation of artificial heads will be completed. A second study aimed at enhancing a method for measuring the occlusion effect based on the human voice, and begun as part of the previous work, will be conducted. The focus will be on evaluating and objectifying the comfort provided by hearing protectors in terms of all their physical, functional, and psychological dimensions,

in order to provide (i) preventionists and OHS managers in enterprises with guides for choosing more appropriate protectors for each worker, and (ii) manufacturers, with tools for quantifying comfort (comfort indices) and for integrating comfort into their design process by means of virtual and experimental comfort testers. A project on earplug comfort was proposed in this regard and should begin during the new five-year cycle. This work will be carried out in partnership with a multidisciplinary team that includes the École de technologie supérieure de Montréal, the INRS in France, and Sheffield University in the United Kingdom. It will rely heavily on the infrastructures of the ICAR laboratory, which was inaugurated in 2011.

#### 2.3.4.1.6 SHORING AND SHIELDING SYSTEMS

##### Aims

The aims of this program are twofold: (1) to provide preventionists with tools that will help them choose appropriate means of protection against trench cave-ins, taking into account soil type and conditions and water table conditions, and (2) to support the work of the review committee for Québec's *Safety Code for the Construction Industry*.

##### Progress report

Workers carrying out excavation and trench work are exposed to risks of cave-ins that can cause death or serious injury (48 fatalities and 17 serious accidents in Québec between 1974 and 2013, primarily due to lack of shoring or of safe work methods). In light of this problem, a study aimed at producing a soil classification system and a method for selecting shoring systems for trench excavation began in 2017. This study, which is the last under this program, will make it possible to classify

soils in Québec urban areas based on their geotechnical characteristics, by rock type and three or four types of soil in decreasing order of stability, and to develop a simple method for determining soil type *in situ*, so that excavation and shoring work can be carried out safely. This program is 75% complete.

##### Developments anticipated during the cycle

The last soil classification project will be finalized and will wind up this program. Upon completion, the program will have provided a means of evaluating the shoring and shielding systems used to guard against trench cave-ins and a method for classifying the types of soil found in urban areas, as well as a simple method for determining soil type *in situ*, thus facilitating the process of selecting a shoring system based on this classification. Users will have the tools they need to choose an appropriate system incorporating geological, geotechnical, and structural factors.

#### 2.3.4.1.7 RESISTANCE OF PROTECTIVE GLOVES AND CLOTHING TO MECHANICAL AND PHYSICAL HAZARDS

##### Aims

This thematic program studies protective gloves and clothing for the purpose of evaluating their resistance to mechanical hazards (such as cuts, punctures, tears, and adherence) and physical hazards (such as temperature), while incorporating aspects related to human factors. The work involves developing knowledge of the behaviour of materials in the presence of different types of hazards and of the impact of using equipment on physiological functions, motor function, and comfort. This in turn makes it possible to develop tools for selecting protective clothing and test methods, and to establish equipment selection criteria and contribute to the development of standards and more effective products.

##### Progress report

The part of this research program on glove resistance to mechanical hazards is currently being completed. Three studies anticipated in the 2013-2017 five-year plan are now finished. The first concerned glove resistance to multiple mechanical hazards. It provided a better understanding of cutting and puncture mechanisms combined with elastomer membranes, and made it possible to develop a test method for characterizing the resistance of these materials to perforation by a pointed sharp object. The second study sought to determine the effect of industrial contaminants on protective gloves' resistance to mechanical hazards. It characterized the effect of cutting fluids on the puncture/cut resistance of protective gloves

in controlled laboratory conditions and in the workplace. A third study involving the upgrading of the *Protective Gloves Selection Guide* microsite is currently under way. This upgrading concerns both the content and technological aspects, and incorporates the results of the latest IRSST research work published on protective gloves, in the form of selection parameters (resistance to needle puncture) and sample cases (multiple risks, contaminants), as well as updates concerning standardized test methods. This part of the thematic program yielded a glove selection guide and a standardized method for testing cut resistance using the TDM-100 machine. The method was developed by the IRSST at the end of the 1980s and has undergone continual improvements since then, making it now the best known method for this purpose in Europe, the United States, and around the world.

Regarding the human factors and protective clothing component of the program, an agreement has been signed by the IRSST and UQAM for joint use of a controlled environment laboratory (CEL), allowing work to be carried out on the physiological effects of wearing protective clothing in both warm and cold environments (-20 to +40 °C). Two studies were also launched. The first, which was conducted in the CEL, evaluated two new technologies (heat absorption systems and new materials used in the composition of firefighter clothing) designed to reduce the heat stress to which firefighters wearing personal protective clothing (PPC) are subjected. The results showed that the introduction of phase-change materials as a system of heat absorption, in the form of a vest worn inside PPC, significantly reduces thermophysiological responses. The researchers also showed that measurements of temperature and humidity levels inside the PPC appear to serve as a good indicator for evaluating the performance of materials used in firefighter clothing. The second study, completed in 2016, involved an

ergonomic analysis of the thermal comfort and mobility of motorcycle police wearing bullet-proof vests, and the development of criteria for selecting or designing vests better adapted to this type of work.

Lastly, a student was awarded a postdoctoral fellowship to continue developing a method for characterizing the resistance of protective textile materials (used for gloves or clothing) to perforation by a sharp pointed object, as well as new treatments for increasing this resistance. This thematic program is 75% complete.

#### **Developments anticipated during the cycle**

New studies to evaluate the performance of new technologies used in protective materials will be proposed. In particular, they will evaluate breathable, waterproof membranes designed to reduce the thermal stress associated with wearing firefighter PPC. The postdoctoral trainee's work on the resistance of textile materials will be finalized. The agreement signed with Groupe CTT (a multiservice centre for the textile industry) should support research efforts in this area.

Given that the part of the thematic program on protective gloves has ended, thought will be given in the new five-year cycle to redefining this program by focusing more, for example, on evaluating the physiological constraints associated with wearing protective clothing and equipment. Among other things, there are plans to explore the needs of the food sector (work in refrigerated zones) and the fire safety sector (evaluation of new technologies for firefighter clothing and equipment, monitoring of physiological signs of on-duty firefighters). The pertinence of either redefining or ending this thematic program and of proposing a new one on smart protective clothing will be evaluated.

### **2.3.4.1.8 PROTECTION AGAINST FALLS FROM HEIGHTS**

#### **Aims**

This program concerns the development and application of test methods for identifying the personal protective equipment (lanyards, safety harnesses, belts, and anchoring systems) and collective protective equipment (guardrails and horizontal lifelines) best adapted to different work environments, taking human factors into account. The work on safety harnesses is also intended to serve as a basis for developing new products, defining selection criteria, and supporting the development of standards.

#### **Progress report**

A study on the degradation and aging of vertical lifelines that was anticipated in the 2013-2017 five-year plan was completed. Its aim was to establish the impact of prolonged weathering on the properties of certain vertical lifelines, particularly their mechanical resistance. Seven types of rope were studied and subjected to accelerated aging in a laboratory climate chamber and to natural static aging (sunshine and bad weather, but without being used). Using the results obtained, the evaluated ropes were classified in three categories after the aging treatments. The loss of resistance to traction ranged from negligible to major. The compelling results of this study provide encouragement



for broadening the scope to include other PPE such as safety lanyards (tethers) and harnesses.

The 2013-2017 five-year plan also anticipated a possible study that would model the dynamic behaviour of guardrails (simulation of the shock sustained by a person hitting a guardrail top plate), but this did not take place. The plan further proposed taking human factors, such as comfort and ergonomics, into account for personal protective equipment, and the need to consider anthropometric changes in the population (heavier body masses) if applicable. It also indicated that the reasons why harnesses are not worn would be evaluated. However, these studies were not feasible during the 2013-2017 period, and priority was given to two new studies on horizontal lifeline systems (HLLSs). In fact, given that it had become mandatory to equip lanyards with energy absorbers further to amendments made to Québec's *Safety Code for the Construction Industry* in 2001, a study was conducted on this aspect. It involved updating the technical guide for designing horizontal lifelines. In addition to this study, a calculation tool for design engineers working on active fall protection systems to protect against falls from heights was recently posted on the IRSST's Web site. The other study evaluated a horizontal lifeline system and the anchorage connectors used during residential roof installation. It was carried out at the joint request of ASP Construction, the Association des Maîtres couvreurs du Québec (AMCQ), and the CNESST. The study evaluated an HLLS designed by a Québec builder in order to render it more effective, user-friendly, and reliable by improving the installation method and making it lighter. It also sought to verify the strength of braced roof trusses used as a host structure for the HLLS according to the usual construction site practices and of the three CSA Z259.15-certified anchorage connectors, the ones most frequently used of the six selected. This work was completed, and a technical fact sheet on the HLLS will be developed by the IRSST in collaboration with ASP Construction in the context of a knowledge transfer activity. This program is 50% complete.

### **Developments anticipated during the cycle**

This thematic program has two components: one on collective protective equipment and the other on personal protective equipment (PPE). To date, the program has focused more on the first. It is now anticipated that a study will be conducted on the resistance of wooden guardrails fastened onto new structures and on the behaviour of metal guardrails subjected to loading and fastened onto existing structures. However, in the new cycle, the focus will shift to PPE. The research work will revolve mainly around the following aspects: (1) the development and application of test methods for identifying the PPE (lanyards, safety harnesses, and anchorage connectors) best adapted to different work environments, (2) the characterization of ergonomic and comfort constraints in order to promote the wearing of this equipment, while taking the human factors into account, and (3) the aging of PPE made of textile fibres. The new work will involve studying the interaction between the various components of a personal fall-arrest system (lifeline, self-retracting lanyard, safety harness, fixed anchorage point, deadweight anchorage point, horizontal lifeline, etc.), the ergonomic factors, and the integration of this equipment into the work performed by various trades. The projects will take into consideration the arrival of so-called "smart" equipment on the market. They will seek to determine the pertinence of opting for this new type of equipment over the traditional counterparts and to document its advantages, disadvantages, and possible limitations. Regarding the aging of PPE, it may be the opportune time for continuing the work done on the static aging of vertical lifelines, by examining the impact of aging and of lifeline use on construction sites to study the combined aging/use impact on the performance of this equipment, through dynamic fall tests. Lastly, the research work will attempt to evaluate the impact of amendments to the standard (CSA Z259) on workplaces, to put forward recommendations regarding the design of new products and the definition of selection criteria, and to support the development of future standards. Two studies begun in 2017 as part of the PPE component will be completed. The first study is seeking to validate the strength of a roof drainage structure as a host structure for a lanyard, and the second, to evaluate safety harness comfort in simulated work conditions and in suspended positions.

### 2.3.4.1.9 PREVENTION OF SLIPS AND FALLS IN OUTDOOR WORK ENVIRONMENTS

#### Aims

Authorized during the 2013-2017 cycle, this thematic program is aimed primarily at assisting workplaces that require outdoor work with the process of selecting equipment suited to their particular work environment and context, ultimately to prevent slips. The program has two research orientations: (i) work contexts and determinants of slips, trips, and falls, and (ii) the links between the characteristics of boots and other footwear and slips.

#### Progress report

A knowledge transfer activity was carried out to meet the needs expressed by workplaces. The aim was to develop a technical fact sheet that could help in the selection of safety footwear in terms of slip resistance. The information pamphlet produced provides information and raises awareness, among members of occupational health and safety committees and those in charge of purchasing safety footwear, of the importance of applying certain criteria when selecting a model. One research activity compared methods for measuring the coefficient of friction in order to determine the slip resistance of winter work footwear on icy surfaces (measured in the laboratory and biomechanical tests with human subjects). The quantitative slip-resistance measurements obtained should result in informed recommendations to workplaces to help them select appropriate work footwear. This thematic program is 25% complete.

#### Developments anticipated during the cycle

During the 2018-2022 five-year cycle, the study on methods for measuring the friction coefficient of winter work footwear on icy surfaces will be completed. In addition to stepping up already-initiated collaborative projects



(Toronto Rehabilitation Institute, McGill University), it is anticipated that work will continue on methods for evaluating the slip resistance of various types of soles using both mechanical and biomechanical methods that take the human factor into account. This work will shed more light on the capacity of winter footwear to deliver optimal traction that will allow workers to perform their tasks efficiently and safely. Specifically, efforts will be made (i) to quantify the slip resistance of the heel and forefoot of winter footwear during various work tasks performed by human subjects, for example, walking at various speeds, accelerating, or going around obstacles; (ii) to assess the possibility of doing tests with human subjects on sloped surfaces, using a method similar to one that was standardized in Germany and is now widely used in Europe; and (iii) to optimize the method for measuring icy surfaces with the SATRA machine (a method currently standardized for floors) in order to obtain measurements closer to those obtained with human subjects. There are also plans to explore the possibility of collaborating with an at-risk sector on the determinants of slip, trip, and fall accidents in a work context (research orientation 1 of the thematic program).

### 2.3.4.1.10 AUDIBLE ALARM SIGNALS IN THE WORKPLACE

#### Aim

Authorized during the 2013-2017 cycle, the aim of this thematic program is, upon completion, to have generated comprehensive knowledge with a view to providing workplaces with guides and clear recommendations that will permit optimal use of alarm signals, whether generated by fixed alarms or reverse (back-up) alarms on moving vehicles or structures. It has two components. The first focuses primarily on transferring the knowledge of alarm signals developed by the IRSST together with stakeholders in the field. The second is concerned mainly with audible reverse alarms and with exploring the potential of virtual acoustics applied to alarms.

#### Progress report

Three studies were carried out during the 2013-2017 cycle. A first knowledge transfer activity concerned the development of video documents designed to inform enterprises and workers of the effectiveness of broadband reverse alarms and to raise worker awareness of the sound emitted by this new device. Two videos (French and English) were posted on the IRSST's Web site. A project that involved evaluating the performance of reverse alarms in open workplaces was also conducted with a view to optimizing their use. It yielded recommendations regarding values for the signal/noise ratio (level of alarm relative to level of the ambient noise) that will minimize the



risk to worker safety by reducing the annoyance caused by excessively high noise levels. A better understanding of the operation of alarms with self-adjusting noise levels was gained and documented. Moreover, the results concerning the adverse effects of poor alarm installation made it possible to provide OHS practitioners with objective data that will serve as better guides. Lastly, a proof-of-concept activity was completed on the reproduction of industrial sound environments in the laboratory, using advanced technologies with applications to audibility studies or alarms and other audible signals. It evaluated the capacity of this system to reproduce and faithfully simulate complex virtual sound environments (such as those found in industrial settings) in the laboratory. It is now possible to conduct various audibility studies in the laboratory with human subjects, alarms and audible warning devices, hearing protectors, etc., while varying the test conditions and environments, which is difficult to do in industrial settings. A fourth study was begun during the 2013-2017 cycle to determine the impact of wearing hearing protectors and safety helmets on the perception and localization of reverse alarms. The impact of hearing protectors was first investigated in an earlier study, which showed that they could, in certain cases, play a major negative role. This thematic program is 75% complete.

### Developments anticipated during the cycle

It is anticipated that work will be done to evaluate, with workplace stakeholders, which types of knowledge transfer tools would be most appropriate for presenting and transferring the knowledge acquired in the previous cycle on the performance of reverse alarms in open workplaces, ultimately to ensure optimal use. Lastly, it is expected that the potential of highly directional speakers for possible application in the case of reverse alarms will be evaluated. These types of speakers should make it possible to create an alarm signal heavily concentrated behind the vehicle in the danger zone, while minimizing the environmental annoyance caused outside this zone as well as other undesirable effects, such as interferences due to ground reflections. If such technology were to prove useful, it could also be used for fixed alarms. This study will wind up this thematic program. Upon program completion, all the knowledge acquired, as well as the resulting guides and clear recommendations, should enable workplaces to make optimal use of alarm signals, whether generated by fixed alarms or by reverse alarms on moving vehicles or structures.

## 2.3.4.1.11 IMPLEMENTATION AND SAFE USE OF COLLABORATIVE ROBOTS

### Aims

During the 2013-2017 cycle, it was anticipated that a thematic program related to control systems and automation would be proposed. However, as the spectrum covered by this research theme was too broad, it was decided to limit it to a specific and emerging area of application with respect to OHS risks: collaborative robots (cobots). This new thematic program was authorized in 2016.

The aim of this program is to design methods and tools that will help enterprises implement and use collaborative robots in the workplace safely and efficiently. It has two components, each associated with a specific phase of implementation: (i) the preparatory analysis needed for safe operation of collaborative robots, and (ii) the integration of risk reduction measures recommended for collaborative robot applications.

### Progress report

This thematic program has only just begun. An exploratory study was conducted to identify cobot-related research



issues. The main goal was to evaluate the way in which robots' safety functions, which are processed by safety-dedicated electronic boards, ensure operator protection. It also sought to gather feedback on how safety is factored into collaborative robot integration projects in Québec.

### Developments anticipated during the cycle

During the new five-year cycle, research work is envisaged mainly on the first (aforementioned) component of this thematic program: the preparatory analysis needed for safe operation of collaborative robots. A study will be carried out on safety measures for workstations involving human worker-robot collaboration. To foster a multidisciplinary approach, it will include engineering and ergonomics researchers. This study will make it possible

to acquire the installations and knowledge needed for the next part of the thematic program. Depending on the research opportunities that arise, and given the rapid pace at which this field and the related technologies are evolving, presence-sensing and power- and force-limiting technologies will also be studied. It is therefore planned to acquire and install cobotics infrastructures in the IR SST's machine safety laboratory, and there, to replicate industrial applications in the context of an experimental, adaptive robotic cell.

## 2.3.4.2 THEMATIC PROGRAMS UNDER DEVELOPMENT

### 2.3.4.2.1 ALTERNATIVE METHODS TO LOCKOUT

This program examines the safety of maintenance operations from the angle of alternative methods to lockout. Lockout is a procedure that for many years has ensured worker safety during interventions (maintenance activities, for example) on equipment that has been powered off. Many regulations and standards mention lockout as the main technique for controlling hazardous energy. However, since January 2016, Québec's *Regulation respecting occupational health and safety* has permitted the use of methods other than lockout, provided they ensure equivalent safety. Standard CSA Z460 specifies that if a machine has to be connected to a power supply during the performance of the prescribed task,

alternative methods may be used only if the machine's safety measures allow effective control of all hazardous energies to which the workers may be exposed. These alternative methods are not detailed in the body of Standard CSA Z460, and only a few examples are given in the informational appendices. Enterprises are therefore responsible themselves for ensuring that the alternative method they choose ensures equivalent safety to lockout. But how exactly should this be done? What tools should be used? To help enterprises ensure equivalent safety, this thematic program proposes to identify and validate alternative methods to lockout to, in short, ensure worker safety.

### 2.3.4.2.2 EVALUATION AND SELECTION OF SUSPENSION SEATS

The aim of this thematic program is to make support tools available for selecting the most suitably adapted seats in order to reduce worker exposure to whole-body vibrations in various categories of vehicle. Given that the vibratory environment found in several vehicle categories is created by vibrations coming simultaneously from several directions, it will be proposed to continue developing this research component by taking multi-axis vibrations into account. To develop this thematic program, a first study

consisting of a state-of-the-art review with respect to the reduction of suspension seat vibrations was begun in 2017. It will document the various devices and seat technologies (such as passive, semi-active, and active suspension) that attenuate vibrations in the vertical axis but also in the lateral axes. The results obtained will orient the development of this thematic program, which should be proposed by the end of 2017.

## 2.3.4.3 THEMATIC PROGRAMS TO BE DEVELOPED

### 2.3.4.3.1 MOBILE EQUIPMENT SAFETY

Mobile equipment (tool vehicles) is found in nearly all economic activity sectors (e.g. manufacturing, construction, mining, and forestry). The operation and maintenance of these vehicles exposes workers to hazardous phenomena, mainly mechanical, electrical,

hydraulic, gravitational, thermal, or chemical in nature. The consequences of an accident can be serious or even fatal for both equipment operators and workers found in the vicinity. Mobile equipment has been identified as a major source of danger in many countries. In Québec,

306 CNESST investigation reports on serious or fatal accidents between 2000 and 2013 involved a piece of mobile equipment, representing 38% of all reports for the study period. The problems associated with mobile equipment are, in particular, visibility and blind spots (mobile machine-pedestrian collision), equipment stability, and use beyond capacity (rollover, tipover, and overloading), falling of the load lifted by the machine,

falls from heights (from the top of the equipment), impromptu maintenance operations, remote operation, and reliability of the devices used to ensure worker safety (e.g. human presence detectors and overload sensors). The development of knowledge on one or more of these problems would address a prevention need expressed by our partners.

#### 2.3.4.3.2 SMART PROTECTIVE EQUIPMENT

The growing interest in new, portable technologies (“wearable technologies”) designed for a specific audience (e.g. athletes or health professionals) or even the general public (e.g. smart watches) and that meet various needs raises the question of their impact on prevention in the work world. Several of these technologies have already been, or could be, integrated into work clothing or PPE to measure various physiological parameters (heart rate, body temperature), physical parameters (ambient temperature, noise, UV radiation), chemical parameters (toxic substances), and situational parameters (GPS, communications, falls, etc.). Other technologies now make it possible to minimize the effect of the environment (heat, cold) by controlling clothing temperature by means of a pump that circulates warm or cold liquids through the microchannels embedded in a plastic film integrated directly into protective clothing. The IRSST is currently conducting a review of knowledge on the possible applications of smart textiles in occupational health and safety and the potential risks. With the creation of the Smart Textile and Wearables Innovation Alliance by the National Research Council Canada (NRC) in collaboration with the industry

(30 Canadian companies), a trend is unfolding in Canada that could make it a world leader in this emerging sector. Moreover, a collaboration agreement regarding research on fall protection equipment and physical, chemical, and biological hazards in the workplace was signed by Groupe CTT and the IRSST in 2016. Given this context and the fact that consultations with our partners have revealed a need for the comprehensive assessment of PPE, the IRSST will evaluate the pertinence of proposing a thematic program on the real benefits of smart protective equipment and the OHS risks it may pose. The program development process will have to take into account the current redefinition of the thematic program on the resistance of gloves and protective clothing to mechanical and physical hazards. The latter may, for example, serve as a springboard to a thematic program on smart protective equipment by being expanded, if need be. The pertinence of retaining only one thematic program on the subject as opposed to two will be assessed.

### 2.3.5 WORK OUTSIDE THEMATIC PROGRAMS

Numerous studies and knowledge transfer activities aligning with this research field’s orientations but lying outside the thematic programs were carried out during the 2013-2017 cycle. The work concerned the risks associated with noise, vibrations, machine safety, slips and falls, protective equipment, and the safety of underground structures. Some of these studies will continue in the new five-year cycle. The following paragraphs briefly identify the work accomplished during the 2013-2017 cycle, according to the risk studied. They also position this work relative to the research orientations.

### **Noise (orientations 1 and 3)**

Work was carried out to improve acoustic diagnostic tools. This included (i) measuring effective intra-aural noise exposure in the workplace by developing an intra-aural measurement technology, (ii) identifying the position of noise sources in the workplace by means of a microphonic antenna, and (iii) analyzing the propagation of transient noises by means of modelling tools. The first two projects are currently under way and will continue in the new cycle, while the third has been completed. Another study was carried out to document the use of hearing prostheses in noisy work environments.

### **Vibrations (orientations 2 and 3)**

The current work on means of protection for reducing hand-arm vibration will be concluded during the 2018-2022 period. More specifically, this work involves assessing the performance of anti-vibration gloves in attenuating vibrations in the palm of the hand and fingers, while taking the ergonomic factors associated with wearing these types of gloves into account.

### **Machine safety (Orientation 1)**

A number of studies have been conducted on this topic, mainly in relation to maintenance. The first, which is still in progress, involves collecting the data needed to analyze and classify machine-related accidents into “maintenance” or “production” categories, in order to document these accidents, and ultimately to identify the most appropriate preventive actions. The second, also under way, is seeking to identify possible solutions that would make the cleaning, disinfection, and inspection phases safer, while complying with the sanitation requirements of the agri-food industry. These two studies are expected to end soon. A third study analyzed maintenance interventions, but also production interventions on plastic injection molding machine in order to evaluate worker safety. Risk assessment and analysis of risk reduction measures were also performed.

Two other studies currently under way will continue during the new cycle. They concern the safe design of machines, and involve (i) updating a technical fact sheet on mine hoists used in Québec and (ii) gaining better insight into the practices and needs of Québec machine manufacturers with respect to the safety of their products, ultimately to prevent work accidents at the source.

### **Slips and falls (orientations 1, 2, and 3)**

The aim of a first study was to identify the causes of accidents and the main risks factors associated with slips and falls in order to propose possible avenues of research that would ultimately meet workers’ needs in two particular occupations: police officer and school crossing guard. Three other studies investigated falls overboard in the lobster fishing sector. In the course of these studies, the risks and their determinants were analyzed, the activities and layouts of two main workstations on lobster boats were documented, and lastly, the ergonomics and safety of both workstations were improved. All this work is now complete.

### **Protective equipment (orientations 2 and 3)**

A first research study, currently under way, is measuring the impact of wearing a reusable P100 filter mask on various physiological variables, depending on physical effort, temperature, and relative humidity. A second study led to the development of a comprehensive reference site on heat stress analysis by grouping together all recognized and internationally well-documented heat stress indices. Lastly, a third study is now producing a synthesis of the knowledge on smart textiles and identifying technologies, solutions, and products with possible OHS applications, as well as the potentially associated risks.

### **Safety of underground structures (orientations 1 and 2)**

One study developed a predictive model that represents the central tendency and real dispersion of rock strains and is free of the biases that can be introduced by inappropriate measurements in the field and by the limitations of current techniques. This model is applicable to northwestern Québec, particularly to mines located along the Cadillac fault. A second study was undertaken to advance knowledge on the interaction between fill and containment structures (rock faces and barricades), ultimately to provide the mining industry with a tool for designing safer and more reliable barricades.



## 2.4 OCCUPATIONAL REHABILITATION



### CONTEXT

From 2006 to 2012, the number of people in Québec's active labour force rose from 3.74 million to 4.01 million, up by 7%. The increase was particularly high in certain subgroups of workers, including landed immigrants (24%) and workers aged 55 or older (36%). It was also higher among women (9%) than men (5%). During the same period, the annual number of CNESST-accepted occupational injuries continued to decline (-28%)<sup>1</sup>. However, the number of injuries with rehabilitation<sup>2</sup> rose by 3%, meaning that the proportion of injuries with rehabilitation rose from 5% of all cases in 2006 to 7% in 2012.

From 2010 to 2012, we witnessed an annual average of 6,200 injuries with rehabilitation accepted by the CNESST, or 7% of all injuries. The proportion was higher for cases involving musculoskeletal disorders (MSDs) (10%) than those involving traumatic accidents (5%). These types of injuries also have major repercussions. The average duration for traumatic accidents with compensated lost time and rehabilitation was 608 days compared to 48 days for traumatic accidents with compensated lost time but no rehabilitation. For MSDs, these durations were respectively 627 days and 53 days. The average duration of sick leave among workers requiring rehabilitation was thus 12 times longer than that for workers not requiring rehabilitation.

### GOAL

Occupational rehabilitation research helps to prevent or reduce the risks of long-term disability in workers who have sustained work-related injuries, and to support the service offerings of the CNESST as well as clinical and workplace interventions, whether in the context of the return to work (RTW) or sustainable job retention (SJR) following injury. More specifically, it uses evidence-based data to support the safe and sustainable return to work of injured workers. This is achieved by studying (1) the various individual, organizational, administrative, and healthcare-system-related factors that facilitate or hinder a smooth RTW or SJR process, and (2) methods of intervention aimed at rehabilitating workers and reintegrating them into the labour force.

### RESEARCH ORIENTATIONS

The activities conducted under the Occupational Rehabilitation research field revolve around four main orientations:

1. Development of tools for assessing the health of workers who have sustained work-related injuries and are at risk of disability
2. Study of the personal, clinical, organizational, and administrative determinants of a **sustainable**<sup>3</sup> return to work
3. Development and implementation of rehabilitation and **sustainable**-return-to-work interventions
4. Development and implementation of tools designed for professionals working in the area of rehabilitation and **sustainable** return to work

<sup>1</sup> This document does not take traumatic accidents or MSDs into account.

<sup>2</sup> Injuries *with rehabilitation* are those for which the CNESST made payouts for rehabilitation costs or for income replacement indemnities related to rehabilitation (IRR\_DP04).

<sup>3</sup> The notion of sustainable RTW solutions refers to sustainable job retention.



## 2.4.1 PUTTING THE FIELD'S PRIORITY ISSUES INTO PERSPECTIVE BASED ON STATISTICAL DATA

Of the roughly 6,200 injuries with rehabilitation that were accepted annually by the CNESST during the 2010-2012 period, 31% involved back injuries. Of the accepted traumatic accidents<sup>4</sup> (TrAs) and back-related MSDs, injuries with rehabilitation represented 8% and 9% respectively of the cases, but over half of the compensated days and payouts<sup>5</sup>. The back ranked second among the anatomical sites involved in TrAs with rehabilitation, accounting for 14% of the cases, while it ranked first for MSD injuries, representing 48% of the cases.

Apart from the back (48% of the cases), the two other most frequent anatomical sites for MSDs with rehabilitation were the shoulder (19%) and multiple sites (7%). This order remained the same, regardless of sex, age group, and occupational category. The breakdown of TrAs with rehabilitation by anatomical site was more uniform, and it was not the back that ranked first. In fact, it was multiple-site injuries that were most frequently involved (17% of the cases), followed by the back (14%), hand-finger (11%), knee (10%), and shoulder (10%). The first two of these five sites had a relatively higher frequency among women, and the last three among men. Moreover, the hand-finger site represented a higher proportion of the TrAs with rehabilitation among workers in the aged 15 to 24 group (21%), while the shoulder site was more frequent in cases involving workers aged 55 or over than in the other age groups. Lastly, the hand-finger site was also overrepresented in manual labourers compared to the other two occupational categories (non-manual and mixed).

Two-thirds of the accepted MSD injuries with rehabilitation involved sprains/strains, followed by musculoskeletal problems (except the back), which accounted for 24% of the cases. These two injury types characterized

approximately 90% of these MSD cases, regardless of age group, sex, or occupational category. As for accepted TrAs with rehabilitation, the five main types of injury were as follows: sprain/strain (31% of the cases), fracture (20%), bruising/contusion (12%), mental disorder (8%), and open wound (7%). Fractures and open wounds represented a larger proportion of rehabilitation cases involving men (23% and 9% respectively) and manual workers (22% and 9% respectively), while psychological disorders accounted for a larger proportion of cases involving women (14%), non-manual workers (19%), and workers aged 15 to 24 (13%).

Taking both TrAs and MSDs into account, workers in five occupations listed in the 1971 Canadian Classification and Dictionary of Occupations (CCDO, 3-digit codes)<sup>6</sup> and accounting for the highest volume of accepted cases with rehabilitation sustained 45% of these injuries. The five occupations in question were (1) material handlers (12% of all TrAs and MSDs with rehabilitation), (2) nursing, therapy and related assisting occupations (9%), (3) other construction trades occupations<sup>7</sup> (9%), (4) motor transport operating occupations (9%), and (5) other service occupations<sup>8</sup> (6%). Moreover, turning to the occupations having the highest proportion of cases with rehabilitation, three had proportions equal to or higher than 10%.<sup>9</sup> In order, these were (1) specialized workers (textile, fur, and leather products), (2) farmers, and (3) forestry and logging occupations.

Again referring to the 2010-2012 period, the probability of rehabilitation in cases of CNESST-accepted TrAs or MSDs varied depending on certain personal characteristics. In particular, a slightly higher proportion of women had injuries with rehabilitation than men (8% versus 7%). Age correlated even more strongly with this proportion.

<sup>4</sup> Traumatic accident (TrA): A work-related accident that does not involve an MSD. It includes cases involving injuries sustained or illnesses contracted as a result of falls, impacts, being struck, caught, or crushed by an object or piece of equipment, colliding with something, accidental exposure to harmful substances or environments (electricity, extreme temperatures, chemical or biological substances), transportation accidents, fires or explosions, assaults or violent crimes, as well as injuries resulting from rubbing or abrasion caused by friction or pressure.

<sup>5</sup> Under section 184.5 of the *Act respecting industrial accidents and occupational diseases* (AIAOD), rehabilitation measures may also be offered to workers before they are medically consolidated. Technical aids and some of the costs of occupational therapy services that help them regain functional capacities may be treated as medical aid costs. Without being able to say exactly how much, it is important to remember that some rehabilitation costs may be counted as medical aid costs. Therefore, the results indicated probably represent an underestimation of the payouts related to rehabilitation.

<sup>6</sup> In 2010-2012, 81 different CCDO 3-digit codes were associated with at least five CNESST-accepted traumatic accidents and/or MSDs (with or without rehabilitation).

<sup>7</sup> These are the trades classified under code 8799 of the CCDO. This code includes workers not classified elsewhere under the major group coded 879. Examples are elevator adjusters, carpet layers, and pipeline maintenance workers.

<sup>8</sup> These are the trades classified under code 6199 of the CCDO. This code includes workers not classified elsewhere under the major group coded 619. Examples are parking-lot attendants, sanitary services workers, and commercial divers.

<sup>9</sup> Of the occupations including an average of at least 15 accepted cases with rehabilitation per year.



The proportion of accepted TrAs with rehabilitation was only 2% in workers aged 15 to 24, but increased to 5%, 7%, and 8% respectively for workers aged 25 to 44, 45 to 54, and 55 or over. The increase was even bigger for MSDs. In increasing order by age group, the proportions were 3%, 9%, 12%, and 14%. The duration of injuries (TrAs and MSDs combined) with rehabilitation was also 20% longer in men than in women, and 22% longer for workers aged 55 or over than for those aged 15 to 24.

The proportion of cases with a relapse, recurrence, or aggravation was approximately 3% of accepted TrAs and 4% of accepted MSDs. These proportions rose to 14% and 15% respectively for accepted TrAs and MSDs with rehabilitation. The proportion of these injuries with rehabilitation that resulted in a relapse, recurrence, or aggravation was the same for men and women. However, it was lower for stress-related TrAs (8%) than for the other types of TrAs (15%).

The number of TrAs involving stress-related psychological injuries<sup>10</sup> evolved in the same way as the number of all TrAs attributable to other causes, with the proportion of stress-related TrAs remaining stable at 2.0% from 2005 to 2012. However, these cases represented 7% of all compensated

days during the 2010-2012 period, and, on average, stress-related injuries lasted three times longer than injuries with other causes.

Four industries accounted for more than two-thirds of the accepted stress-related injuries: healthcare and social aid (23% of cases for which the industry was coded in 2010-2012), transportation and warehousing (20%), trade (13%), and public administration (12%). Workers in the transportation and warehousing sector were particularly overrepresented among the victims of this type of injury. While they represented only 4% of the active labour force, 20% of the accepted stress-related injuries occurred in this activity sector. The most frequently affected occupations in this sector were bus drivers (63% of the cases for which the occupation was coded) and truck and delivery drivers (14%).

Lastly, it was impossible to obtain the number of psychological injuries associated with a physical injury, as psychological injuries were included in the same event file and counted as physical injuries in the CNESST's statistics (MSDs or TrAs).

## 2.4.2 PUTTING THE FIELD'S PRIORITY ISSUES INTO PERSPECTIVE BASED ON RESEARCH MAPPING AND SCIENTIFIC MONITORING

The mapping of occupational rehabilitation research provides a portrait of scientific efforts in this field and of the specific areas generating the greatest interest. It also points to new problems. The mapping exercise involves comparing our work to that of our Canadian and international counterparts.

For the Occupational Rehabilitation research field, mapping of the 2011-2016 period led to the identification of 152 studies conducted by research organizations such as the National Institute for Occupational Safety and Health (NIOSH) in the United States; the Health and Safety Executive (HSE) and the Institution of Occupational Safety and Health (IOSH) in the United Kingdom; the Institut national de recherche et de sécurité (INRS) in France; the European Agency for Safety and Health at Work (EU-OSHA); the Netherlands Organisation for Applied Scientific Research (TNO); WorkSafeBC (WSBC) in British Columbia and the Institute for Work and Health (IWH) in Ontario,

Canada; Liberty Mutual in the United States; Safe Work Australia (SWA) and the Institute for Safety Compensation and Recovery Research (ISCRR) in Australia; the National Research Centre for the Working Environment (NRCWE) in Denmark; and the IR SST.

Regarding the research orientations of the Occupational Rehabilitation field, the one generating the most activities among the achievements mapped is the study of the individual, clinical, organizational, and administrative determinants of a sustainable return to work (42%). The development and implementation of rehabilitation and sustainable-return-to-work interventions ranks second (32%). The development of tools for assessing the health of workers who have sustained work-related injuries and are at risk of disability, as well as the development and implementation of tools designed for professionals working in the area of rehabilitation and sustainable return-to-work, generate less interest and are virtually tied

<sup>10</sup> The CNESST compiles data on stress-related psychological injuries under two categories of events: traumatic (death, serious accident, armed robbery, physical violence, death threats, etc.) or chronic (harassment at work, stress related to the job or to work organization, etc.).

well behind the other two research orientations (at 9% and 10% respectively).

Of the research field's themes and programs, support for interventions in clinical settings ranks first (36%). Risks of long-term disability among workers (22%) and support for RTW and SJR processes in enterprises (19%) are virtually tied in second place, while the protection of workers in vulnerable situations comes last (7%).

Trends in research priorities are emerging for the years ahead. Occupational reintegration into a job other than the pre-injury job is already a theme generating interest in nearly two-thirds of the studies mapped in the 2011-2016 period. In an effort to reduce the number of cases of occupational injuries resulting in a change in jobs, the United States and British Columbia are now prioritizing the development of best practices and moving toward integrated prevention, from primary prevention to tertiary prevention (which includes rehabilitation).

Support for small- and medium-sized enterprises (SMEs) is the focus of emerging concern in Canada, especially British Columbia, where it was a research priority in 2017. In Québec, the CNESST described (in its 2017-2019 strategic plan) its concern with aligning itself with the current labour market context, where over two-thirds of all workers are employed by enterprises with 20 to 99 employees.

A number of institutions, such as NIOSH, Safe Work Australia, the NRCWE, WorkSafeBC, and the Prevent-

Foundation in Belgium (on behalf of the European Union), maintain programs that prioritize research projects aimed at developing psychological health knowledge, mainly pertaining to prevention, but some also relating to rehabilitation. At these same organizations, in addition to ongoing interest in studies on traumatic psychological injuries, the priorities and desired projects in rehabilitation now concern chronic stress- or violence-related psychological injuries in the workplace, particularly psychological harassment.

Mapping of the 2008-2010 period signalled the emergence of new themes, such as that of workers in vulnerable situations. Gender, aging, and a growing number of workers from ethnocultural minorities are considered subjects related to workers in vulnerable situations, and are eliciting growing interest in rehabilitation. In Canada, this trend appears to be continuing. The IWH in Ontario is continuing its work in this regard, and British Columbia made it a research priority for 2017. Researchers in the United States are also interested in the theme, as is the Federal Institute for Occupational Safety and Health (BAuA) in Germany. In Québec, a recent report from the Montréal's director of public health mentioned the increased risk of occupational injuries for workers from temporary employment agencies. It says that these workers very often come from ethnocultural minorities. The CNESST is also particularly concerned about older workers, immigrant workers, and workers from ethnocultural minorities.

### 2.4.3 PUTTING THE FIELD'S PRIORITY ISSUES INTO PERSPECTIVE BASED ON NEEDS EXPRESSED BY PARTNERS

To develop this new five-year plan, the IRSST met with various social partners in the fall of 2016 to sound out their knowledge needs. One of these groups focused more specifically on issues related to occupational rehabilitation.

Several issues that emerged from these partner consultations are already the subject of research projects under the current themes or programs in this research field, while others may be so in the future. These issues concern, in particular, the study of populations in vulnerable situations (covered in the “workers in vulnerable situations” program), the dissemination of best practices in rehabilitation and sustainable return to work (covered under the “support for clinical interventions” and “support for enterprises” themes), study of the role and involvement of the attending physician (“support for clinical interventions” theme), development of tools to support managers and human resources advisors

(“support for enterprises” theme), a point that is of particular interest for small enterprises, and the cost-benefit evaluation of effective interventions (“support for enterprises” theme). This underscores the pertinence of the field's current research themes and programs.

Other issues raised by numerous partners relate to those identified by the researchers in this field. They not only attest to the relevance of the current themes, but also shed light on the possibility of developing future themes and programs. They concern the issues of sustainable job retention, occupational reintegration, especially among workers who have to integrate into a job other than their pre-injury job at the same employer's or elsewhere on the job market, as well as psychological injuries.

For the 2018-2022 five-year cycle, special attention will therefore be paid to sustainable job retention following a sick leave caused by an occupational injury, which

also pertains to one of the objectives presented in the CNESST's 2017-2019 strategic plan: "Effectively support victims of occupational injuries to promote their timely and sustainable return to work" (p. 23). A future theme or program could thus focus on occupational reintegration.

Lastly, greater attention must also be paid to the issue of psychological injuries that can occur in the workplace, as numerous partners are seeking solutions for workers affected by such problems.

## 2.4.4 RESEARCH PROGRAMS AND THEMES

Several initiatives now under way or being developed pertain to the three main needs identified in the previous section (1. sustainable job retention, 2. occupational rehabilitation, and 3. psychological injuries), but also to the assessment of interventions and the attention to be placed on the needs of small enterprises. Generally speaking, the needs relating to sustainable job retention or psychological injuries fit in with the current thematic program or research themes. Psychological injuries could be studied under two themes: (1) risk factors for long-term disability among workers and (2) support for RTW and sustainable-job-retention processes in the workplace by developing interventions in the workplace and tools for rehabilitation counsellors who assist all the professionals,

social partners, and workers affected by injuries having a psychological component.

The needs expressed by our partners concerning occupational reintegration and those relating particularly to the small enterprise context appear to require special attention, given that little research has been done on these issues to date.

The (a) current themes and thematic programs, and (b) the themes and thematic programs to be developed are presented a little further on. Tables 1 and 2 below show the developments anticipated in the research programs and themes, as well as their classification by research orientation.

**Table 1** Developments and changes anticipated for the 2018-2022 five-year period

	PROPOSAL
<b>THEMATIC PROGRAM</b>	
Protection of and support for workers in vulnerable situations	Maintain
<b>RESEARCH THEMES</b>	
Risk factors for long-term disability among workers	Expand (SJR)
Support for interventions in clinical settings	Maintain
Support for RTW and SJR processes in the workplace	Expand (SJR)
<b>PROGRAM OR THEME</b>	
Occupational reintegration of workers into a job other than their pre-injury job	Develop
<b>INTERFIELD PROGRAM OR THEME</b>	
Adaptation of solutions for small enterprises	Develop

**Table 2** Breakdown of programs and themes by the field’s research orientations

	ORIENTATION 1	ORIENTATION 2	ORIENTATION 3	ORIENTATION 4
<b>CURRENT THEMATIC PROGRAM</b>				
Protection of and support for workers in vulnerable situations		x	x	x
<b>CURRENT RESEARCH THEMES</b>				
Risk factors for long-term disability among workers		x		
Support for interventions in clinical settings	x		x	
Support for RTW and SJR processes in the workplace			x	x
<b>PROGRAMS OR THEMES TO BE DEVELOPED</b>				
Occupational reintegration of workers into a job other than their pre-injury job	x		x	x
Adaptation of solutions for small enterprises			x	x

## 2.4.4.1 CURRENT THEMES

### 2.4.4.1.1 RISK FACTORS FOR LONG-TERM DISABILITY AMONG WORKERS

#### Aims

It is a well-known fact that a small proportion of workers who have sustained occupational injuries develop a long-term disability and account for most of the payouts. The aims of this research theme are to define the predictors of long-term disability and identify the groups at highest risk. Acquiring knowledge of the main indicators and of the relationship among these indicators and developing prediction tools are therefore crucial to facilitating a timely, safe, and sustainable return to work.

#### Progress report

This theme has undergone developments, mainly with regard to the question of personal predictors of disability. The study of personal risk factors covers emotional and cognitive factors, physiological factors, and workers' sociodemographic characteristics. Three studies have been completed. The first examined the clinical and neuromechanical determinants of low-back disability by focusing on various types of measures obtained during clinical examination (pain, perceived disabilities, and psychological factors) or in the laboratory (motor capacities and pain-modulation mechanisms). The second looked at the magnitude of workers' worries during the RTW as a factor potentially interfering in the rehabilitation and RTW process, and at the need to clarify these worries in order to identify possible courses of action. Following up on a literature review, researchers are currently documenting the determinants of a RTW after knee arthroplasty (replacement), from the perspective of the worker, his or her work environment, and health professionals, again to come up with possible courses of action. Lastly, a study of the impacts of an early screening program for workers with low back pain could not be carried out due to problems related to the field study.

#### Developments anticipated during the cycle



A degree of consensus is emerging to the effect that the risk factors for work disability are relatively well known when it is a matter of predicting a work absence following an initial injury. However, additional work is needed in this regard. For example, the feeling of injustice, which is a risk factor for long-term disability, will be studied to determine the factors that cause it to emerge.

Other needs pertaining to the risk factors for relapse have also been identified. One of these is sustainable job retention (SJR). In fact, the risk factors for sick leave following an initial injury (the issue examined in the vast majority of studies to date) are perhaps not exactly the same as the risk factors for relapse (following a RTW). Researchers will study this question in workers with an MSD or a common mental disorder (CMD) in relation to age. The study of sustainable job retention will also require identifying and probably establishing indicators for SJR (or for relapse). In other words, this task will have to be carried out at the very beginning of the cycle. Once the indicators used to date have been identified, they, together with new knowledge emerging from future studies, will be integrated into a Web site currently being developed on work disability. This site will be enhanced throughout the cycle.

### 2.4.4.1.2 SUPPORT FOR INTERVENTIONS IN CLINICAL SETTINGS

#### Aims

The aims of this research theme are to improve interventions in the healthcare system to ensure the most effective action, and to speed up the rehabilitation process in order to initiate workers' gradual or full RTW, while ensuring their safety and services better adapted to their specific needs.

#### Progress report

The 2013-2017 five-year cycle was marked by the production of major knowledge reviews that were broad in scope and co-funded through the IR SST-REPAR partnership. The first concerned knee osteoarthritis, and the second, shoulder injuries. Follow-up projects are currently in progress. The first one is studying RTW determinants in workers who have undergone knee replacement (as mentioned in the previous section), while the second is developing clinical practice guidelines for optimizing management of workers and promoting the RTW of workers with shoulder injuries.



With regard to tools for assessing worker health, the results of a preliminary study aimed at developing clinical prediction rules concerning treatment outcomes (i.e. the response of workers with low back pain to a specific exercise program) were compelling and necessitate ongoing work. For the upper extremities, methods and indicators based on 3D movement and internal imaging of the shoulder structures were developed to explain the functional limitations of the shoulder, in turn leading to additional technical developments aimed at relating other indicators to shoulder function.

Many projects were carried out on clinical interventions, beginning with populations having musculoskeletal injuries. A guide for evaluating the margin of manoeuvre available in work situations for individuals with long-term musculoskeletal disabilities is currently being produced. A vast study co-funded by the IRSST and the Fond de recherche du Québec – Santé (FRQS) resulted in the development and implementation of a program for shared decision making (occupational therapist and worker) about the RTW, taking into account other stakeholders (insurers, employers, unions). In addition to developing a training program that is now being offered with the collaboration of the Ordre des ergothérapeutes du Québec, this study offers clinicians involved in occupational rehabilitation programs a systematic way of helping workers make decisions about their RTW. Another study identified the contextual factors, components, and mechanisms that appear to explain the success of occupational rehabilitation programs for workers with MSDs.

Regarding psychological injuries, the validation of a screening questionnaire for transient mental disorders was completed, and an innovative intervention combining a pharmacological component with the usual treatments for workers suffering from post-traumatic disorders is currently being evaluated. Moreover, a few studies investigated musculoskeletal and psychological injuries simultaneously: these included the validation of a questionnaire designed to identify obstacles to the RTW and measure the worker's feeling of self-efficacy; and the validation of a guide (in the form of a work disability diagnosis interview) that comprehensively assesses the causes of the long-term disability, thus identifying potential targets for clinical interventions. These two tools will help clinicians establish an intervention plan for facilitating a safe and sustainable return to work. Lastly, a preliminary evaluation of a rehabilitation program designed to facilitate the RTW of individuals suffering from musculoskeletal pain and depression is now in progress.

### Developments anticipated during the cycle

Based on the preliminary results obtained, work is expected to continue on developing a clinical prediction



rule for identifying those workers with low back pain who have the highest probability of responding well (or of not responding) to a program of low back stabilization exercises. If the results are also compelling, this tool would then be validated through a randomized clinical trial. A platform for evaluating and following up on workers with an MSD involving an upper extremity will also be created to offer clinical settings a systematic and standardized protocol for interventions with this particular clientele. Regarding psychological health in the workplace, there are plans to adapt the guide for evaluating the margin of manoeuvre available in the work situation, this time for workers with disabilities related to psychological health disorders. These projects will be followed by an assessment of the degree of implementation of both margin-of-manooeuvre evaluation guides (for musculoskeletal and psychological disorders).

Four projects will involve both musculoskeletal and psychological disorders. The first pertains to the needs expressed by partners with regard to sustainable job retention. Also anticipated is an assessment of the impact of using a questionnaire developed during the previous cycle specifically to identify obstacles to the RTW and measure the worker's feeling of self-efficacy in overcoming them. Following the development and implementation of the program for shared decision making by occupational therapist and worker, the process will be adapted and

its effectiveness evaluated in order to potentially extend it to decision making by the worker during the RTW process, but taking into account the various stakeholders' constraints. Lastly, it is anticipated that an intervention guide will be developed and implemented as a sequel to the study that investigated worries as a factor potentially interfering in the rehabilitation and RTW process.

In addition, studies are anticipated to evaluate the effectiveness of various tools or interventions, such as the clinical practice guidelines for optimizing the management

of workers with shoulder injuries, or the rehabilitation program designed to facilitate the RTW of individuals with musculoskeletal pain or depression. As expressed by our social partners, it is also hoped that cost-benefit studies will be carried out.

Another study on SJR is anticipated. A psychosocial intervention designed to prevent relapses and recurrences in workers recently back at work following a psychological health disorder will be evaluated.

#### 2.4.4.1.3 SUPPORT FOR RTW AND SJR PROCESSES IN THE WORKPLACE

##### Aims

When workers are ready to begin a gradual or full return to work, the various stakeholders in the process (e.g. insurer, clinic, and workplace) must be involved in order to facilitate a safe and sustainable return. The aim of this theme is therefore to develop interventions or support tools to help each of these stakeholders play their role optimally.

##### Progress report

A literature review revealed that, in enterprises, the usual strategies for preventing disability focus mainly on workers and their clinical trajectory. Given that the process of coordinating efforts among stakeholders in the healthcare system (attending physician and other health professionals), the workplace (direct supervisor, employer, union, RTW coordinator, etc.), and the insurer is only just beginning, it is clear that this theme is in its very early stages. However, compared to previous years, we are seeing more and more research on this theme. In fact, one study described the practices of the RTW coordinator, who plays a pivotal role in large enterprises in Québec. Regarding MSDs, best practices applicable in the Québec context have been described in order to equip organizations to manage their own RTW processes. This work has in fact generated interest, within organizations, in a second pivotal player in RTW, namely, direct supervisors. Work recently began with the aim of proposing courses of action to help them play their role, not only in the RTW but also in SJR. In addition, with regard to MSDs, work began on developing a self-management program aimed at the SJR of workers with chronic pain associated with a low back problem, and will be completed in 2017. Thanks to the use of information and communication technologies, small, medium-sized, and large enterprises will all be able to use this program.

Rounding off work done on psychological injuries during the 2013-2017 cycle, a guide was produced to help organizations support the RTW and facilitate the SJR of this particular clientele. Another study identified the

factors influencing the RTW of workers with depression, from the perspective of union representatives. It also revealed the need to clarify the role of union stakeholders with these workers. Some work had already been done during the 2013-2017 cycle on interventions for workers who have suffered post-traumatic stress. Further work is now in progress, with an innovative activity involving peers (colleagues) in their capacity as actors in the healthcare sector.

Lastly, the content of a Web site on disability and RTW, including the enterprise's perspective, will be developed in the 2018-2022 cycle. The work will culminate with a knowledge transfer activity in the form of the online launch of the Web site, and will thus disseminate the best occupational rehabilitation practices for reducing long-term disability.

##### Developments anticipated during the cycle

In addition to current work that will be completed and other projects that will be presented, special attention will be paid to SMEs in order to generate knowledge that will assist them in developing RTW practices adapted to their particular context.

Regarding SJR, the development of an overall integrated prevention approach (primary, secondary, and tertiary) aimed at reducing long-term disability and facilitating the RTW following musculoskeletal or psychological disorders is envisaged. This approach will involve developing a tool that equips organizations to identify the psychosocial risks requiring action, thus facilitating collective (e.g. participatory approach) and organizational prevention efforts. This approach will then be evaluated.

The development and validation of a process for defining, implementing, and evaluating policies and procedures concerning disability prevention, RTW, and SJR in Québec organizations will also be proposed. The aim will be to provide managers and human resources departments within organizations with new tools, a need expressed by our social partners. The effectiveness of an RTW and



SJR self-management program will also be evaluated. This study will include a cost-benefits analysis component, from the employer perspective. In fact, as with interventions carried out in clinical settings, it will eventually be

necessary to demonstrate the cost-effectiveness of interventions carried out in the workplace, through a cost-benefits study.

## 2.4.4.2 CURRENT THEMATIC PROGRAM

### 2.4.4.2.1 PROTECTION OF AND SUPPORT FOR WORKERS IN VULNERABLE SITUATIONS

#### Aims

Workers in vulnerable situations include individuals who, based on their sociodemographic or occupational characteristics and the work contexts they may be associated with, run a higher risk of sustaining occupational injuries or experiencing long-term disability. Three worker populations have been singled out and used to create three distinct program components: (1) immigrant workers and workers from ethnocultural minorities, (2) older workers, and (3) workers with gender-based vulnerability. The objectives are the same for all three components: (1) identify the workers' occupational trajectories, (2) gain insight into the work contexts that expose them to greater vulnerability, and (3) contribute to the development of RTW support tools customized to the specific needs of the various stakeholders (clinicians, workplaces, insurers).

#### Progress report

##### *Immigrant workers and workers from ethnocultural minorities*

This component of the program, initially presented and accepted in 2013, is the furthest along. First, a statistical surveillance study provided a portrait of the Québec immigrant labour force and documented the characteristics of the work they perform, as well as the risks to their health and safety. This was followed by a large-scale study on the experience and perspective of each type of party involved in the rehabilitation and RTW process in an intercultural context (workers, clinicians, CNESST professionals, workplaces), to better identify constraints, obstacles, facilitators, and specific needs. The results of this study will serve as the foundation for the projects aimed at properly equipping the various stakeholders concerned.

##### *Older workers*

This component of the program was presented and accepted in March 2015. A call for proposals launched in April of the same year resulted in the start-up of work



related to the program, through the funding of two projects that examined, respectively (1) the obstacles, facilitators, and issues associated with the occupational reintegration, RTW, and SJR of older workers with work-related disabilities, and (2) current practices of organizations in these three regards. Such projects, with their focus on the situation in Québec, complement those of Ontario's Institute for Work and Health, which is currently doing a systematic review of the risk factors identified and interventions proposed at the international level.

Furthermore, an activity piloted by the IRSST's Statistical Knowledge and Surveillance Group and now nearing completion will shed light on the factors that influence the duration of compensation, by age group and sex, which in turn will inform this component of the program.

##### *Workers with gender-based vulnerability*

While the literature often identifies women as being in vulnerable situations, an overview is needed to verify this assumption. In fact, the results of some studies are not all that clear, which explains the choice not to target a specific gender (men or women) to start with. The aforementioned activity of the Statistical Knowledge and Surveillance Group will help advance knowledge on this issue.

Presented and accepted in September 2016, this component of the program includes two themes that are being studied simultaneously and that involve (1) the identification of the

obstacles-facilitators-issues that influence the RTW and SJR (differentiated analysis based on gender) and (2) the gender-based adaptation of RTW and SJR intervention models. A call for proposals launched through the IRSST-REPAR partnership resulted in a review of the literature on the first theme, and more specifically, with regard to MSDs. More recently (winter 2017), both themes were the subject of an awareness-raising activity for the researchers in our network, with a view to generating projects through the collaborative research program. Some researchers showed interest. Projects are therefore expected to commence during the 2018-2022 cycle.

### Developments anticipated during the cycle

#### *Immigrant workers and workers from ethnocultural minorities*

An activity initiated by the Statistical Knowledge and Surveillance Group concerning this particular worker population will inform this component of the program.

To meet clinicians' needs regarding intercultural communication (language barriers, cultural gaps), one study will look at the working alliance between immigrant workers and their therapists to pinpoint the types of alliances preferred by workers and practitioners, as well as their relative importance in the attainment of the treatment objectives. Responding to a CNESST request, it was proposed that a process be developed for co-constructing an intercultural communication support tool for practitioners. Another activity will involve a two-day training session that presents the factors hindering and facilitating implementation of intercultural competency in organizations that deliver health services.

#### *Older workers*

The earlier work will continue, and a complementary study will explore the issues and challenges faced in the rehabilitation of older workers.

Following the publication of the IWH's systematic review in Ontario and of IRSST-funded studies, it will then be

possible to undertake work on effective intervention models for occupational reintegration, RTW, and SJR. This work (successive studies) is expected to run beyond the 2018-2022 cycle. Similarly, a questionnaire will be developed to document work accommodations put in place to facilitate the sustainable RTW of older workers with work-related physical or psychological injuries. Another study will, through a co-construction process with the stakeholders involved, develop, implement, and evaluate innovative integrated interventions designed to foster more effective management of these workers, but also disability prevention, occupational reintegration, and SJR.

#### *Workers with gender-based vulnerability*

As mentioned earlier, the first studies should begin during the 2018-2022 cycle. To complement the information gleaned from a literature review on this topic, a study will be proposed on women's and men's perceptions of the RTW obstacles and facilitators faced by workers with MSDs. Then, in light of the results obtained, an intervention aimed at reducing the duration of MSD-related sick leaves will be developed and evaluated in terms of its effectiveness and its cost-benefit ratio. These successive studies are also expected to extend beyond the 2018-2022 cycle. Particular attention will have to be paid to identifying the obstacles, facilitators, and issues influencing the RTW and SJR of workers (differentiated gender-based analysis) having work-related disabilities that are associated with psychological injuries, because only MSDs were investigated during the 2013-2017 cycle.

Moreover, some Québec research teams have approached the IRSST as a potential partner for Phase II of a joint CIHR/SSHRC initiative entitled "Healthy and Productive Work." The aim of this initiative is to support new, innovative approaches to facilitating the integration of individuals with work-related health problems or disabilities into the labour force. The results of this competition will be announced in 2018, and the IRSST may support one or more projects on vulnerable workers that align more directly with its program.

## 2.4.4.3 THEMATIC PROGRAMS OR THEMES TO BE DEVELOPED

### 2.4.4.3.1 OCCUPATIONAL REINTEGRATION OF WORKERS INTO A JOB OTHER THAN THEIR PRE-INJURY JOB

Workers who have sustained occupational injuries that leave them with permanent functional limitations sometimes have to change jobs, a particularly difficult challenge when they have to reintegrate elsewhere than at their original employer's. This finding, which emerged from a study published by the IRSST in 1994, is still

applicable today, but has not been the subject of any more specific studies.

During an audit of the CNESST's files from 2014 to 2016, the Auditor General of Québec (VGQ) made several recommendations and observations, one of which was "(...) few indicators are used to show the sustainable nature

of the RTW or the quality of rehabilitation interventions, such as the number of returns to pre-injury jobs or better follow-up of the results of the return-to-suitable-employment process.”

A group of physicians made a request to the IRSST concerning the evaluation of functional limitations because, in their view, the evaluation tools available to them need to be updated. By way of response, the Scientific Division

will have developed, by the end of 2017, a strategy for studying functional limitations, particularly in the context of occupational reintegration.

Based on this strategy and as part of the development of this new thematic program, it is proposed to continue defining the problem of reintegration into an other-than-pre-injury job.

#### **2.4.4.3.2 ADAPTATION OF SOLUTIONS FOR SMALL ENTERPRISES**

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This thematic program is to be developed in collaboration with the Sustainable Prevention and Work Environment research field.

## 2.5 RESEARCH PLANNING TOOLS

### 2.5.1 STATISTICAL KNOWLEDGE AND SURVEILLANCE

The Statistical Knowledge and Surveillance Group (SKSG), which reports to the IRSST's Scientific Division, is responsible for using existing databases (population-based surveys, surveys, administrative data on occupational injuries, etc.) to produce, develop, analyze, and disseminate statistical indicators. These indicators concern worker populations, occupational injuries, and worker exposure. New sources of administrative data on the labour market that are produced by Statistics Canada offer exceptional opportunities for research on workers and enterprises. The SKSG intends to explore and use these new data sources over the coming years.

The SKSG's activities are intended specifically to support the Institute's strategic orientations and research

programs. The aim of the statistical surveillance work is to identify activity sectors, occupations, and populations at risk; detect trends; highlight some of the research issues related to the research fields; and provide recurrent statistics on specific problems. The statistical knowledge studies document OHS-related indicators, situations, or problems to help improve understanding of the contributing or explanatory factors.

The work carried out by the SKSG falls into three main categories: statistical surveillance, statistical knowledge, and dissemination and application of results. These activities may be carried out either on an aggregate basis (i.e. for all injuries or workers) or by individual research field.

#### 2.5.1.1 STATISTICAL SURVEILLANCE

Since 2006, a research-field analysis approach has been added to the more aggregate statistical surveillance that looks at all accepted occupational injuries with or without

compensated lost time in Québec. These two approaches remain pertinent for the new five-year cycle.

##### 2.5.1.1.1 AGGREGATE SURVEILLANCE

Every five years, the SKSG carries out statistical studies that measure the risk, severity, and cost of occupational injuries by industry, occupational category, age, and sex. It also analyzes the characteristics of the occupational injuries. These studies are used to provide an overview of activity sectors in Québec by means of OHS indicators. The SKSG has therefore produced these indicators after each census period (2001, 2006, and 2011). As these five-year indicators are useful for establishing research orientations, this activity will continue in order to produce indicators

for 2016, based on the 2016 census and CNESST data. The methodology may be revised to take into account a shorter data maturity period attributable to the faster availability of labour force data.

While essential for establishing statistical portraits, these five-year indicators do not identify short-term changes and trends. For this purpose, intercensal annual indicators will be produced for the 2012-2016 period, using a similar process to that used to produce the annual indicators for 2007-2012.

##### 2.5.1.1.2 SURVEILLANCE BY FIELD

The purpose of statistical surveillance by field is to produce statistical indicators and metrics specific to a given

research field or an issue studied in that field. However, the data available for each research field or theme can vary

greatly. This surveillance work will continue by updating the statistical indicators and metrics specific to each field,

based on the needs voiced by the Scientific Division and the research field leaders and coordinators.

### 2.5.1.2 STATISTICAL KNOWLEDGE

The work on aggregate statistical knowledge involves documenting the situations for all injuries by age, sex, occupational category, industry, or characteristics of the injuries or workers, for example. More often than not, it involves work specific to the SKSG, which also entails methodological developments to produce new indicators.

The statistical knowledge associated with the research fields is generated through the collaboration of members of the SKSG in projects and activities undertaken by

the researchers in a given field when these projects or activities have a major component involving the acquisition, processing, and analysis of administrative or survey data. This collaboration is now more important than ever because the members of the SKSG have greater expertise not only with compensation data, but also with population-related survey data, databases on worker exposure, and data sources that can be used to calculate the costs of employment injuries.

#### 2.5.1.2.1 AGGREGATE KNOWLEDGE

Regarding aggregate statistical knowledge, work is planned to document certain factors (aging and cost of injuries) likely to have an impact on various aspects of occupational health and safety (OHS), as identified by some of the research fields. The aims of this work will be to describe and measure the phenomenon and understand its determinants or effects on OHS. Among other things,

there are plans to conduct a study on differential aging by industry and occupational category.

Regarding the cost of injuries, the IRSST's consultations with partners and researchers reveal great interest in evaluating the cost-effectiveness of prevention activities. A study of the costs and benefits of occupational injury prevention will therefore be carried out.

#### 2.5.1.2.2 KNOWLEDGE BY FIELD

With regard to knowledge by research field, members of the SKSG participate in activities or projects that have a component involving the analysis of population, injury, exposure, or cost data. For example, in the Sustainable Prevention and Work Environment (SPWE) field, members

of the SKSG will participate in activities and projects falling under thematic programs or research themes such as the "cohabitation of diverse populations in the workplace" and the "integration of young workers into the labour market."

### 2.5.1.3 RESULTS DISSEMINATION AND APPLICATION

The dissemination and application of results is now an integral part of research activities and projects. Members of the SKSG contribute to and collaborate in such activities, which are coordinated by a knowledge transfer advisor.

With the creation of the *Statistiques sur mesure* microsite in 2015, the SKSG now has a platform for disseminating the main results of its statistical outputs. This activity will continue during the 2018-2022 period.

### 2.5.1.4 OTHER ACTIVITIES

In addition to statistical knowledge and surveillance activities, the SKSG team will continue to carry out service and expert appraisal activities for internal and external researchers. These activities may also be carried out in

response to requests submitted by one of the Institute's social partners (sector-based associations, CNESST, INSPQ, etc.) when they are deemed pertinent and authorized by the IRSST's Scientific Division.

## 2.5.2 SCIENTIFIC MONITORING BY FIELD

The Institute's research program is based mainly on analysis of data obtained from scientific monitoring. Among other things, this analysis makes it possible to stay abreast of changing trends in OHS research, to position the IRSST relative to the main OHS research centres elsewhere with regard to certain themes, to identify emerging problems relevant to the Québec context, and to enhance the project development and implementation process. More specifically, during the new cycle, scientific monitoring will focus on three components: mapping by field, information monitoring, and producing status reports. Reflection will also begin on the possibilities of integrating two new components into the process: knowledge brokering and foresight.

The development of a map for each of the Institute's priority research fields consists of drawing up a portrait of the studies conducted in the leading OHS research centres around the world by identifying the themes and topics studied. The most recent maps were produced in 2016 for each of the research fields, and were, in fact, referred to in the preceding sections. New maps will be produced to lay the groundwork for the next five-year program. We anticipate taking advantage of our partnership agreements with OHS research institutes in Canada and around the world to foster the exchange of information, which will in turn inform the maps.

Information monitoring is ongoing, with the support of the IRSST's documentation centre staff. It involves collecting, selecting, and analyzing documents likely to examine elements that are relevant to the development of OHS research. Thus, the Institute's thematic blogs on its research fields are informed by the daily monitoring of over 650 Web pages. During the new cycle, it is anticipated that work on possible breakthroughs in this field will be carried out jointly with the documentation centre staff.

Status reports will continue to be produced in each of the fields to support the development of thematic programs or thematic research and meet ad hoc needs. These reports will provide a snapshot, at any given time, of the key issues related to a specific OHS problem. Depending on the magnitude of the problem and the interest generated by certain status reports, the IRSST will disseminate the content to a broader public, or possibly in scientific publications.

During this new cycle, the methodological framework for foresight will be explored to anticipate changes in occupational risks and identify emerging issues over the longer term. Reflection will also begin on current knowledge brokering practices.

## 2.5.3 SCIENTIFIC EVENTS AND ACTIVITIES

Scientific events and activities are designed to revitalize activity in the Institute's research fields. In particular, they help ensure the Institute's leadership position by taking stock of specific topics and themes, identifying research issues, informing reflection on potential research projects or programs, and sharing research results or new

approaches. These events and activities can take different forms such as colloquia, seminars, workshops or informal meetings among researchers and sometimes partners in the OHS network. They will continue in each of the fields during the 2018-2022 period.





# 3. THE NEXT GENERATION OF RESEARCHERS AND MANAGERS

Given the central role played by researchers and managers in achieving the IRSST's mission, one of the institutional priorities is to ensure a new generation of both. It is important to remember that the challenge regarding new researchers is two-edged as it concerns not only the Institute's own scientific personnel, but also the many external researchers (universities, and public and private

research centres) who help advance OHS knowledge. The challenge is not a new one. The issue was raised in both the previous five-year plan and the 2017 institutional evaluation report, in view of the many anticipated retirements. During this new five-year cycle, the IRSST will act on two fronts: by means of an internal succession plan and by consolidating or growing its external researcher pool.

## 3.1 INTERNAL SUCCESSION PLAN

A number of employees will become eligible to retire over the next few years. In fact, the Institute estimates that no less than 24% of its personnel may opt to retire within five years. It therefore intends to develop a succession plan that will equip it to face these many departures more effectively and to integrate new resources smoothly. This workforce planning activity will be vital to maintaining the Institute's leadership position and must be part of a long-term strategy. As such, thought will be given to the best practices for staffing, integrating, and retaining a qualified new generation of employees in light of the strategic challenges facing the Institute. In preparation for employees' departures or promotions, a succession organization chart will be created in each division to pinpoint positions having major impact and give priority to analyzing them. This tool will be helpful in analyzing recruitment needs and will facilitate the development of human resources internally for all activity sectors and each employment group. Also envisaged is a transfer

of knowledge for the most critical positions to ensure continuity in projects and operations.

More specifically with regard to the next generation of researchers, in recent years the IRSST has launched various recruitment and training initiatives for promising internal resources. Since 2010, certain employees who have shown aptitudes for and interest in graduate studies have been trained in targeted sectors (Mechanical and Physical Risk Prevention, Chemical and Biological Hazard Prevention, OHS Problem Prevention and Rehabilitation) to enable them to pursue a research career. As this approach has borne fruit, the Institute intends to continue along the same lines. Two employees currently enrolled in graduate study programs will earn their PhDs in the next few years in the disciplines of toxicology and ergonomics, where positions will become vacant. A third employee working in analytical chemistry may embark on a similar path. Efforts are currently under way to recruit an experienced researcher who could also act as leader

of the Occupational Rehabilitation research field. More generally, a succession plan for the role of field leader will be implemented to enable interested researchers to acquire the necessary skills and prepare to take over the reins when such positions are vacated. Plans are also in the works to groom two certified industrial hygienists (CIHs) to work in the laboratories. Lastly, insofar as possible, a pool of potential candidates will be formed with a view to filling the various laboratory positions as they become vacant.

As a complementary strategy, the IRSST will continue to welcome seasoned researchers into its research fields in a variety of ways, such as hosting guest researchers from abroad who are on sabbatical or professional development leave, or through service loans or exchanges between research institutes. In addition to opening the doorway to new and fruitful research collaborations, the fact of attracting experienced researchers to the Institute,

some of whom may wish to stay on a more permanent basis, may help to fill the gaps left when experienced scientists retire.

The replacement of departing management staff will also become a strategic issue in the years ahead. In 2009, the Institute introduced a planning program that was beneficial in this regard. However, a new cohort of managers is expected to retire within the next five to seven years, making it imperative to develop a new action plan for filling the various positions that will be vacated. The advancement of employees to management positions is desirable and even encouraged when they acquire the necessary competencies and skills. To this end, Mosaic HEC Montréal was commissioned to identify the critical knowledge involved and come up with ways of building a repertoire of best practices to ensure the intergenerational transfer of management knowledge.

## 3.2 EXTERNAL SUCCESSION PLAN

As a funding organization, the IRSST is deploying a vast array of measures and programs to cultivate an external cohort of collaborators in occupational health and safety (for example, through regular funding programs, special competitions, contractual agreements, partnerships, and research chairs). The effect of these measures has been significant: in 2017, the Institute had over 275 external scientists and collaborators actively engaged in OHS research. Even so, the Institute must remain vigilant, as this community too is facing an attrition phenomenon driven by the retirement of university researchers.

In the context of the new five-year plan, the communication plan will be updated to create greater visibility for the Institute's funding programs and more direct contact with researchers wishing to do OHS-related research. The Institute plans to pursue strategies such as stepping up its canvassing efforts at universities and research centres, but also among promising researchers whose disciplines or expertise correspond to the IRSST's priorities. It intends to hold Open Houses to present its funding programs to groups of researchers interested in OHS (e.g. researchers in the Pôle santé des HEC, which is the healthcare management hub of the HEC business schools).

Three research chairs currently benefit from the Institute's support: the *Chaire en analyse des risques toxicologiques en santé humaine* (chair in human-health toxicological risk assessment) of the Université de Montréal, the CIHR-IRSST Research Chair in Gender, Work and Health of

McGill University, and the Chair in Work Rehabilitation of the Université de Sherbrooke. This support is yet another means of rejuvenating the researcher pool and increasing the number of research projects and activities, and it will continue over this next period.

Over and above the support it lends to established researchers, the Institute is also an important player in the training of the next generation. It administers a graduate studies scholarship and postdoctoral fellowship program, which itself represents a large pool of promising young scientists. It is worth noting that 95% of the respondents (81 external researchers) in a 2017 survey underscored the IRSST's exceptional contribution to training the next generation of OHS researchers in Québec. The scholarship program alone supports some 30 students doing master's or doctoral programs or postdoctoral training.

However, the number of scholarship applications has decreased over the past three years (83 applications in 2015-2016, 76 in 2016-2017, and 52 in 2017-2018). The IRSST's scholarship offerings will therefore be re-examined to ensure that the amounts offered remain competitive compared to those offered by other funding agencies, all within the Institute's budget limitations. A benchmarking exercise will also be carried out on a regular basis to keep abreast of the best practices in scholarship program management. Additional efforts will be made to better publicize this program in the hopes of reaching a broader audience. An explanatory document will be drafted

specifically for students wishing to submit a scholarship application to help them better describe their project's relevance to the Institute's research priorities and strategic orientations. Moreover, an assessment will be carried out during this new five-year cycle to determine whether the scholarship program yields the desired results, in this case, to find out whether the Institute's scholarship recipients are still working in OHS, and above all, in research.

In addition to the regular scholarships offered to master's, doctoral, and postdoctoral students, thematic scholarships are awarded to incentivize the upcoming generation to concentrate their energies in more targeted fields that are experiencing a shortage of researchers to meet their needs. For example, the Andrée Bouchard scholarship was created during the last five-year cycle to encourage studies on gender, work, and health. During this new five-year period, thematic scholarships will be reserved for applicants whose subject of study is related to particular problems such as mechanical risks, work-related road accidents, or other areas where a lack of young researchers is apparent.

For several years now, the Institute has also been involved in hosting and supervising numerous trainees. It is committed to perpetuating this activity (particularly appreciated by research teams), but also to broadening its accessibility to a larger number of trainees, depending on fund availability. As well, it encourages its researchers to codirect master's and doctoral students in their capacity as adjunct professors within university departments, a position most of them hold.

Lastly, given the success of its first special competition involving career scholarships for young OHS researchers, the Institute plans to renew its existing partnership with the Fonds de recherche du Québec in order to motivate high-calibre candidates to move into niches within this specialty, where internal expertise is either absent or insufficient.



# 4. RESEARCH MANAGEMENT

Surveys of the Institute's personnel and external researchers conducted in 2017 revealed a relatively high level of satisfaction. However, according to the respondents and despite marked improvements over the

previous five-year period, certain aspects, particularly those related to the filing of funding applications and the administrative handling of research projects, are still in need of improvement.

## 4.1 RESEARCH FUNDING APPLICATIONS

On the administrative level, the IRSST hopes to simplify the task of submitting funding applications by making it more user-friendly, and the task of processing the applications once received. It expects to revise its application forms to make them easier to complete and use. Hopefully, and contingent upon obtaining the required financial

resources, new smart electronic forms should go online during this new five-year period. This upgrade should facilitate the entry and exchange of data, as well as speed up the processing of applications. Similarly, a new template will be produced to facilitate the process of estimating the requested research budgets.

## 4.2 ADMINISTRATIVE HANDLING OF RESEARCH PROJECTS

Insofar as possible, the IRSST hopes to reduce the time it takes to process research proposals and thus give targeted users faster access to new scientific knowledge. Over this new five-year period, it will study in detail the various steps involved in the administrative handling of projects (including preliminary analysis, recommendations regarding relevance and priority, peer review, acceptance,

execution, publication) and introduce the measures needed to re-examine, modify, or combine some of these steps to speed up the overall process. A benchmarking exercise will also be carried out to document best practices in the administrative handling and scientific evaluation of research projects in order to draw inspiration from them.

## 4.3 PROJECT MANAGEMENT

A research project well-defined has the necessary foundation to succeed, but that is not the only prerequisite. Optimal project operations also require particular project management skills. And, even when all possible precautions are taken, unforeseen factors can arise and impact project timelines, the resources assigned to carrying them out, and sometimes even the achievement of results. Prompt and appropriate action is then needed to minimize the negative effects.

A project management process was established in 2011 to ensure the best chances of successful research work. Project management involves three important steps: definition, planning, and execution. At the IRSST, project management is expressed in terms of the implementation of a series of progress milestones (*portes*). In short, these involve meetings run by experienced external facilitators with good scientific knowledge. The meetings constitute key times for specifying a project's objectives and how it aligns with the workplace (pre-project planning milestone), for example, and for discussing risk management and resource planning (start-up milestone), the changes to be made to a project that is under way (progress milestone or special milestone), and the successes, failures, and opportunities to grab (post-project evaluation milestone).

The project management process was formally implemented in 2014, initially for internal researchers and then for joint internal/external projects. More recently, wholly external projects have been integrated gradually into this process.

Under the new five-year plan, it is expected that the project management process will be expanded to include a larger number of research projects. As certain scientific activities (activity protocols) pose particular challenges (e.g. complex ethics certificates, multi-disciplinary and

multi-centric teams, research projects involving several parties, special research fields, big budget) could be subject to the process. There are also plans to turn the progress milestone into a compulsory halfway milestone for all research projects tracked through this process. Among other things, this will provide an opportunity for discussion of how projects are progressing, problems encountered, or changes required in any regard, so as to be able to react quickly to problems that arise and ensure that the research work is completed within the initially planned timeframe.

There are also plans to assess the effects of the project management process on the quality/time/resource triad.

In 2016 and 2017, the IRSST offered its research personnel training sessions on the role and responsibilities of project managers and on time and priority management. These sessions were much appreciated and addressed the concerns of the research teams. They will therefore continue during the 2018-2022 period for the purpose of training new researchers and ensuring skill maintenance among current researchers. Moreover, given that the management of several projects at the same time requires particular know-how and skills, it is anticipated that training sessions on project portfolio management will be defined and offered to researchers and scientific professionals responsible for research activities.

Other initiatives will be launched with internal staff and external collaborators to facilitate the exchange of information on particular challenges associated with research project management, such as obtaining complex ethics certificates, working in multi-disciplinary and multi-centric teams, recruiting subjects, carrying out work in special fields, or managing big budgets.

## 4.4 INTELLECTUAL PROPERTY MANAGEMENT

Based on some research proposals submitted to the IRSST, it foresees the development of emerging intellectual property with a view to transferring promising technologies. For example, this could take the form of a particular expertise or a potentially patentable technology that the Institute may want to make available to a third party with a view to exploiting it commercially. During this new five-year cycle, the IRSST will develop a reference framework

including the best practices for supporting researchers in their efforts to potentially protect intellectual property (notably, to obtain patents). This framework will adhere to the Institute's policy on intellectual property and will include procedures for preparing contractual agreements, procedures that are themselves aligned with the IRSST's transfer and commercialization practices.



## 4.5 CERTIFICATE OF ETHICS APPROVAL FOR RESEARCH

For all research activities and projects involving human subjects, it is essential to obtain a certificate of ethics approval from either the IRSST's Ethics Committee (for internal projects) or the ethics committees of the university institutions whose work the Institute helps fund (for projects involving external researchers). In the last few years, the time it takes to obtain such a certificate has lengthened, and the complexity of the process has increased to such a point that it can take months and

sometimes up to a year. The IRSST therefore considers that, during this new five-year cycle, its Ethics Committee should assist internal researchers, as needed, in their efforts to obtain their certificate quickly. It will also study the possibility of using the experience and competencies of the members of its own Ethics Committee to guide internal and external researchers and suggest ways to speed up the process of applying for a certificate of ethics approval and reduce the wait time for obtaining it.



# 5. VISIBILITY AND RESULTS DISSEMINATION

## 5.1 INSTITUTIONAL VISIBILITY

Guardian of the IRSST's image and responsible for its visibility, the Communications and Knowledge Transfer Division (CKTD) promotes the Institute's scientific and technical activities and their results. To fulfill its mandate, the Communications Department of the CKTD sets objectives and develops strategies for reaching its target audiences. These strategies are supported by a variety of tools: the institutional Web site and thematic Web sites, the social media, *InfoIRSST* (the electronic newsletter published in both English and French), and *Prévention au travail magazine* (in French only), as well as videos and webcasts. In addition, every year the CKTD sets up an information booth at events held in the occupational health and safety (OHS) field and at scientific conferences and colloquia.

To support the IRSST's 2018-2022 five-year plan, the Department will develop a strategic communication plan adapted to the institutional objectives and the annual action plans.

### 5.1.1 THE IRSST'S WEB SITES

The IRSST uses the Internet as its priority means of disseminating the results of its research activities and increasing the Institute's visibility. The institutional Web site, available in both English and French, is the main gateway to the Institute's documentary holdings and

other resources. Complementing it are the thematic Web sites, which give Internet users access to targeted knowledge derived from IRSST research and expressed in plain language.

#### **The institutional Web site ([www.irsst.qc.ca](http://www.irsst.qc.ca))**

Through its presence on the Web, the IRSST is able to disseminate the results of its work and grow its reputation and credibility in the field of OHS research.

In 2015, the CKTD went online with its new institutional Web site adapted for electronic tablets and smart phones. This upgraded site differs from its predecessor in that it has adopted the latest best practices regarding Internet publishing, ergonomics, architecture, traffic analysis, and technologies. It hosts more than 1,600 documents.

Visitor traffic data and the number of document downloads will continue to be analyzed thanks to practices implemented in 2016, thus giving us a better grasp of user habits.

The institutional Web site will continue to undergo technological, editorial, and graphic improvements and adaptations to keep pace with evolving user needs, processes, and computer tools. The creation of thematic files will also continue in order to facilitate content searches, as will the implementation of a thesaurus (already in progress).

### Thematic Web sites and Web applications

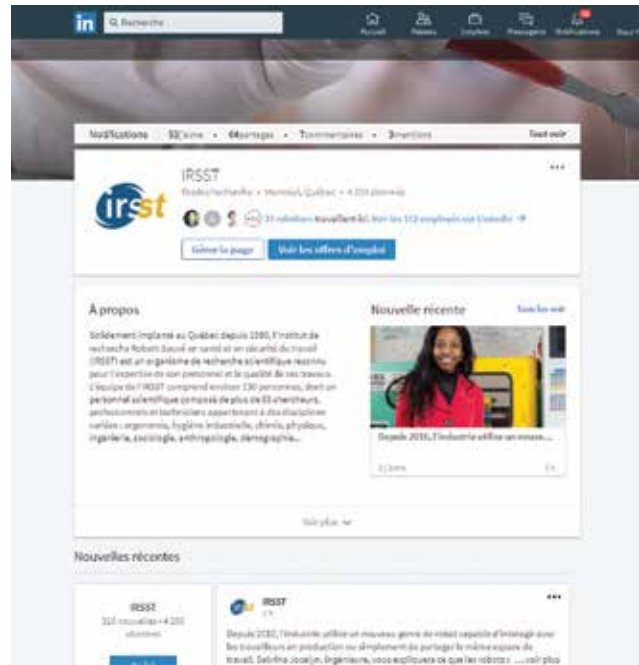
Thematic Web sites provide yet another way of transferring research results and supporting dissemination strategies. Six such sites are currently available: *Manutention en milieu de travail*, *Protective Gloves Selection Guide*, *Statistiques sur mesure*, *Preventing interpersonal violence in the workplace*, *Solub*, and *L'entretien des sols pour la prévention des glissades et chutes de plain-pied*. Moreover, in 2016, the IRSST helped produce the [Jeconcilie.com](http://Jeconcilie.com) Web site on work-study balance. Overall, visitor traffic on these sites continues to grow.

Web applications are also offered online. The two most recent concern respiratory protection against bioaerosols and horizontal lifeline systems (HLLSs) for preventing falls from heights. A third, on risk analysis for interventions in confined spaces, should be offered in 2017.

During the 2018-2022 cycle, the CKTD will continue to perform maintenance operations on these sites and will initiate a reflection process on the relevance of keeping some of them. When necessary, other sites may be produced to support the knowledge transfer strategies.

### 5.1.2 SOCIAL MEDIA

The CKTD ensures the Institute's presence in both the social media and the traditional media. In 2017, the IRSST was therefore present on LinkedIn, Facebook, Twitter, YouTube and Google+, and the number of followers continues to grow. The IRSST intends to maintain its presence in the social media during the new cycle and to continue exploring the new avenues and opportunities afforded by social networking, including, in particular, that of reaching a young audience.



### 5.1.3 InfoIRSST ELECTRONIC NEWSLETTER

The *InfoIRSST* electronic newsletter presents the latest news about institutional activities, new projects, and the most recent publications. It is published in English and French ten times a year and has nearly 5,500 subscribers.

Production of the newsletter is expected to continue, and promotional campaigns designed to introduce it to new OHS actors and target other audiences who are less familiar with the IRSST will be launched to increase the organization's visibility.

### 5.1.4 PRÉVENTION AU TRAVAIL MAGAZINE

Published jointly by the IRSST and CNESST four times a year, the magazine *Prévention au travail* aims to encourage prevention initiatives and their management in all workplaces by providing examples of practical solutions, company profiles, and plain-language presentations of research results. In total, 27,689 copies were published in 2017.

In August 2015, the co-publishers launched the [preventionautravail.com](http://preventionautravail.com) platform to increase readership and awareness of the magazine among Web users and to make it easier to consult articles. Web traffic on the “Recherche à l’IRSST” page of the *Prévention au travail* Web site is constantly on the rise. A subscription renewal campaign will be run in 2018 to update the distribution list.



### 5.1.5 IRSST MENTIONS IN THE MEDIA

The CKTD puts together a media review on a regular basis, including articles in journals, magazines, online newsletters, and Web sites that cite IRSST studies and activities. The decrease in the annual number of mentions witnessed over the 2013-2017 five-year cycle is largely due to the disappearance of a handful of publications or Web sites specialized in OHS. Targeted promotional actions will be taken to support better dissemination of the Institute’s publications to users. In order to increase potential audiences, specific efforts are already under way to reach medical and nursing personnel as well as organizations in the agricultural sector.

The CKTD has also begun exploring technological solutions that could help better document IRSST mentions in both the new and traditional media. These efforts will continue during the new cycle.

### 5.1.6 INFORMATION MONITORING BLOGS

Intended specifically for the scientific community, OHS professionals, and practitioners, the information monitoring blogs provide them with access to the scientific information identified daily in more than 600 sources by the staff at the Institute’s documentation centre.

Given the levelling off in the number of blog consultations over the past two years, a reflection process will begin on possible improvements to their platform and visibility.

### 5.1.7 VIDEOS AND WEBCASTS

In the past few years, the CKTD has continued posting videos online, including lectures, research synopses, reports, and training tools. The institutional Web site now has over 250 videos, and the number of viewings is rising significantly. In 2017, the number of viewings of IRSST videos on YouTube exceeded 150,000, compared with 16,722 in 2013.

The Institute’s video offerings will be enhanced in the coming years, and new initiatives (such as short video capsules) aimed at facilitating access to research results will be pursued.

In addition, webcasting will be encouraged to give a larger audience remote access to events organized by the Institute. For example, this technology will continue to be used to provide broader access to the *Rendez-vous de la science*. This series of monthly lectures, organized and offered by the IRSST, showcases the results of the research, laboratory, and knowledge transfer activities that it supports. The presentations are not only disseminated via webcasts, but also videotaped for viewing on the Institute’s Web site.

### 5.1.8 INSTITUTIONAL AWARDS AND PRIZES

Since 2013, in partnership with the Association francophone pour le savoir (Acfas), the IRSST has handed out two annual awards of \$5,000 each to master's and doctoral students whose work concerns OHS issues. The initiative is intended to encourage the award winners to pursue a research career in this field. The agreement with Acfas will end in 2018. The IRSST may then take stock of the benefits of the partnership and decide whether or not to renew the agreement.

To highlight its 35th anniversary, in 2016 the IRSST awarded a prize to the authors of the best scientific article published in the previous six years in the OHS field. The relevance of relaunching this competition will be assessed in the next few years.

Also in 2016, the IRSST signed a partnership agreement with the Société du Palais des congrès de Montréal aimed at showcasing Québec researchers' contribution to OHS by holding national and international conferences in Montréal. The Institute will give out the first IRSST/Ambassadors Club Joint Award in 2018.

A major promotional activity highlighting these awards and the award winners will be carried out in the years ahead.

### 5.1.9 PRESENCE AT PARTNERS' EVENTS

The IRSST is present at events organized by its OHS partners or other organizations. From 2013 to 2017, staff members hosted IRSST information booths at more than 30 events organized by the Commission des normes, de l'équité, de la santé et de la sécurité du travail (CNESST), Association québécoise pour l'hygiène, la santé et la sécurité du travail (AQHSST), professional associations, and vocational training centres, among others. This strategy will be maintained in the upcoming years and ongoing efforts will be made to identify events where the Institute's presence may be relevant.

## 5.2 DISSEMINATION OF RESEARCH RESULTS

### 5.2.1 RESEARCH REPORTS

To publicize the results of an activity or study that it funds, the IRSST publishes a scientific report, which it posts on the institutional Web site. Over the years, it has built up a sizable document collection. A dissemination plan is also developed for each report and launched when the report is posted online to increase outreach to preventionists, researchers, and anyone else likely to be interested in OHS research and the advancement of knowledge in this field.

The Institute has continued its efforts to translate reports into English to increase visibility for its work among non-Francophones in Québec, in the rest of Canada, and around the world. Relevance, priority nature, scientific merit, target audience, and potential reach are some of the criteria that guide decision making as to whether or not to translate a given document. Nearly 70 reports were translated during the previous cycle, and an English summary was provided for all reports that were not translated.

All activities aimed at increasing the dissemination and reach of IRSST research reports will continue during the new cycle. These activities have a positive impact on the number of visits to the Institute's Web site and of complete downloads of research documents from the site.

### 5.2.2 SCIENTIFIC PUBLICATIONS

Like all research centres, the IRSST strongly encourages its scientific personnel and the researchers whose work it funds to publish their results in the leading scientific journals in their respective disciplines. In this regard, a bibliometric study conducted by the OST (Observatoire des sciences et des technologies, which is a university centre specialized in measuring scientometric indicators) revealed a clear improvement for the Institute during the 2013-2017 five-year cycle with respect to two key indicators: the mean impact factor of the chosen journals and the average relative citation (ARC) value of IRSST articles. This means that IRSST articles are favourably positioned, slightly above the world average. Their publication in reputable scientific journals contributes to the sharing and advancement of knowledge, while allowing researchers to compare themselves to their peers. It also helps consolidate the reputation of the Institute and the work it funds. Efforts to publish in major academic journals will therefore continue in the years ahead.



### 5.2.3 PAPERS DELIVERED AT SCIENTIFIC EVENTS

Every year, the Scientific Division identifies the main standardization committees and major national and international scientific conferences where the IRSST should be present. By participating in such events, researchers guarantee dissemination of the results of Institute-funded research, keep abreast of the latest knowledge, and are ideally positioned to signal emerging problems that could require special attention. The Institute will therefore continue to ensure its strategic presence by sending staff members to major conferences and events during the new five-year cycle.

### 5.2.4 OUTREACH ACTIVITIES

In addition to attending these scientific conferences, IRSST personnel and external researchers give presentations at OHS conferences or events organized by partners in Québec's prevention network. Such events provide opportunities for presenting research results in plainer language so that partners can in turn develop their prevention activities on evidence-based data. The total number of presentations delivered at these types of events and scientific conferences stood at 100 in 2016.

The knowledge transfer efforts made in the past few years may result in the IRSST's involvement in more events of a similar nature in the future.



# 6. LEVERAGING RESEARCH AND KNOWLEDGE TRANSLATION

Regarded as one of the organization's priorities since 2006, knowledge translation (KT) is an integral part of the mandate of the Communications and Knowledge Transfer Division (CKTD). The transfer potential of all research activities is therefore assessed.

However, nothing guarantees application of the knowledge produced. Generally speaking, the knowledge that is generated by OHS research and that could improve practices is underused in the field (Faurie *et al.*, 2013). The implementation of KT strategies poses numerous challenges in terms of facilitating and ensuring the uptake and use of new knowledge by the target users. This is a real issue facing knowledge producers and all stakeholders involved in developing KT strategies.

It is therefore necessary to develop effective KT strategies to encourage the application of evidence-based OHS research results. For this purpose, the IRSST relies on the Knowledge Transfer Department, which is charged with helping create a context or conditions conducive to the use of these results in workplaces.

Basing itself on a framework of practice implemented in 2007, the Knowledge Transfer Department ensures

that knowledge translation is incorporated into research projects and activities right from the earliest stages. The IRSST defines KT in broad terms, including the notions of dissemination, sharing, exchange, mobilization, and application of knowledge. KT goes beyond scientific dissemination, which primarily targets the researcher community, to make results accessible and intelligible to, and usable by, a given public. A knowledge transfer advisor is assigned to each of the IRSST's four research fields to optimize the KT potential. This advisor works in close collaboration with the personnel of the Scientific Division and the Research and Expertise Division, internal and external researchers, and workplaces. In accordance with the KT framework of practice, the advisors ensure continuous interaction between the knowledge producers and the intended users, throughout each of the four main phases of the research and knowledge translation cycle: (1) anchoring in workplace needs and realities; (2) research; (3) knowledge transfer and uptake; and (4) evaluation of impacts.

## 6.1 STAKEHOLDER MOBILIZATION AND GROUNDING IN WORKPLACE NEEDS AND REALITIES

To foster and maintain interaction between researchers and users throughout the process of a study as well as the use of its results, the Knowledge Transfer Department has concentrated its practices on building and maintaining networks of partners representing the main stakeholders concerned (CNESST, joint sector-based associations, worker and employer representatives, professional associations, etc.). This approach adheres fully to the principles of equal (labour/management) representation that characterize OHS activities in Québec. Building and maintaining social networks around OHS problems requires sustained effort and continual adjustment to a context that is constantly changing due to restructuring, retirements, and the arrival of new actors.

During the 2013-2017 cycle, over 320 organizations sat on a follow-up committee at one time or another. These organizations represent a wide range of activity sectors (agriculture, fishing, green jobs, mining, transportation, manufacturing, provincial administration, municipal administration, health and social services, education, construction, and clinical services). Continuing efforts will be made to update the partner network and remain on the lookout for collaboration opportunities.

Meetings are held with workplace representatives prior to submitting funding applications to ensure that the Institute's research is grounded in workplace needs and

realities. As evidenced by the consultations held with partners in the OHS network in the fall of 2016, "grounding" meetings allow researchers to gain a better understanding of the workplace issues and help formalize the partners' commitment to the actual research process. Ultimately, they foster the development of knowledge transfer strategies. The openness to participation displayed by workplaces and the quality of their comments help improve the research aims and objectives. Reflection will continue on the type of support to be given to researchers to raise their awareness of the importance of these meetings and assist them in their preparations.

The IRSST occasionally carries out special consultations (particularly when developing research programs or themes) to identify its partners' needs. Information exchange meetings will be encouraged to confirm the pertinence of these programs and themes, as well as partners' interest in supporting their development before they are presented to the Scientific Advisory Board.

In addition, to support the production of its 2018-2022 five-year research plan, the Institute consulted widely with its partners in order to define and update its list of priority needs. The partners' active involvement in this process attests to the pertinence of using this strategy for the next planning exercise.

## 6.2 RESEARCH AND FOLLOW-UP COMMITTEES

Exchanges take place throughout the research process to support interactions between partners and researchers. Follow-up committees are the IRSST's preferred support mechanism. Coordinated by the knowledge transfer advisors, these committees enable researchers to inform partners of the research progress. They also give the partners concerned by a given research project an opportunity to share their knowledge of the workplace with the researchers.

Every year from 2013 to 2017, approximately 200 organizations were represented on one or another of the IRSST's follow-up committees. Each and every project will continue to be analyzed to assess the pertinence of

setting up such a committee. This mechanism is much appreciated both by internal and external researchers and by partners because it fosters collaborative approaches. At the most recent institutional evaluation, external researchers expressed their satisfaction with this support, which is not usually offered by funding organizations. Partners also confirmed their appreciation of the opportunity to sit on these committees and contribute their expertise, and that they clearly understood the committees' role.

While the follow-up committees have enabled the IRSST to distinguish itself in the past, challenges lie on the horizon for the years ahead. The participants' limited availability

and the regular demands placed on some of them have led to new ways of doing things. Thus, whenever possible and justified, a thematic or sector-based committee will be set up to bring partners together around issues that affect them. This approach will be explored during the new five-year cycle to improve the efficiency of meetings with partners, while giving the latter a clearer overview of the progress being made regarding several topics related to a

shared activity sector or research theme. At present, the construction and health sectors are the focus of such an exercise, and it is proving successful.

Means will also be developed to ensure the continued, if not increased, frequency of communications and interactions with partners for the entire duration of a project in order to keep pace with their reality, address their needs, and promote their involvement.

## 6.3 KNOWLEDGE TRANSFER AND APPLICATION

While the transfer of knowledge is essential for user uptake, a number of conditions are required for this knowledge to be put to use. The Knowledge Transfer Department, in collaboration with partners, determines the most appropriate KT strategies in light of the particularities and issues in each workplace.

In the past few years, the Department's KT products have taken various forms, including guides, technical fact sheets and awareness-raising tools, Web sites and utilities, videos, thematic colloquia, and exchange networks. While some of these products are designed with a specific audience in mind, others are intended for several activity sectors. The calibre of the IRSST's output in terms of the transfer and application of research results was praised by its partners in a survey conducted as part of the 2016 institutional evaluation. They underscored the efforts made to customize and adapt KT products to the needs of the target audiences. The products are usually created in the context of specific KT activities following a study. During the 2013-2017 five-year cycle, more than 30 KT activities were carried out. Developing such activities remains one of the CKTD's priorities for the new cycle, and the analysis of transfer potential, in collaboration with members of the follow-up committees, will continue.

However, KT is not limited only to producing tools. The collaboration of the knowledge transfer advisors with certain communities of professional practice, sector-based liaison groups, and professional associations offers a prime example. However, these efforts are not tallied into the number of officially conducted KT activities, making it difficult to obtain an accurate overview of all KT efforts. From now on, these actions will be better documented to highlight those that pass under the radar despite the time

and resources they require.

The transfer of knowledge to clinicians and practitioners in the health sector remains a major challenge. Despite several projects funded in the Occupational Rehabilitation field with these audiences in mind, analysis of the transfer potential revealed that some of the results are not yet ready to be passed on to these occupational rehabilitation professionals. Nevertheless, KT strategies were implemented during the 2013-2017 cycle, including the organization of lectures exclusively for members of certain professional orders or associations, and activities for OHS professionals and managers at the CNESST.

Reflection continues on the development of the best dissemination and KT strategies. In light of recent research on KT, work will be done to enhance the framework of practice. The objective is to optimize implementation of conditions that foster the uptake of knowledge by means of global, integrated strategies. Given the link between the time when the results of a study are made available and their use, efforts will also be made to carry out KT activities faster. Monitoring activities will continue so as to identify new technologies and appropriate mechanisms, particularly those supporting collaborative approaches such as deliberative workshops.

## 6.4 IMPACT ASSESSMENT

Evaluating the effectiveness of KT strategies remains a key concern for the Knowledge Transfer Department. While partners report that many IRSST-funded products or activities have been useful, and in some cases, have had positive impacts in workplaces, it is still difficult to assess the real benefits. A feasibility study on the evaluation of an IRSST knowledge transfer strategy (Dagenais *et al.*, 2017) was conducted during the 2013-2017 cycle. It systematically documented each aspect of the KT approach recommended by the Institute in order to determine whether it can be evaluated and whether it is possible to measure to what extent the desired effects are

achieved. In addition, a survey of the literature on OHS-related KT and its evaluation was conducted, and a logic model for KT strategies was developed.

A pilot project will be conducted to include measurable or observable indicators in certain KT activities that will be carried out. This will make it easier to assess the impacts. The Institute also participates in the work done by the Research Committee of the International Social Security Association (ISSA), one of whose mandates is to define the contribution of KT research and to understand the impact of this knowledge in terms of reducing the number of occupational injuries.

# 7. DIVERSIFICATION OF PARTNERSHIPS

The only organization in Québec devoted exclusively to OHS research, the IRSST forges links with a number of organized networks of researchers, funding organizations, and research centres, including some of international renown. Partnerships are formed by signing framework agreements or specific agreements, all of which yield many benefits and help shape the Institute's reputation.

From 2011 to 2015, more than 60 agreements were entered into with 54 different organizations, most operating in the research field. Some of these agreements consisted of pooling resources and combining areas of expertise, while others involved financial investments from each of the partners to support scientific activities in particular sectors of OHS research.

The IRSST sometimes expands its pool of collaborators by partnering with organizations and establishments whose mission is not necessarily OHS, but with whom it shares common interests. For instance, the Institute's current agreement with REPAR/FRQS (Réseau provincial de recherche en adaptation-réadaptation of the Fonds de recherche du Québec – Santé) resulted in the launch of a funding program for the production of knowledge reviews on occupational rehabilitation in the case of disabilities of musculoskeletal origin. In addition, the ongoing partnership with the Institut de la statistique du Québec (ISQ) concerning the *Étude longitudinale du développement des enfants du Québec* (ÉLDEQ, or Québec Longitudinal Study of Child Development) will make it possible, thanks to the addition of a new series of questions proposed by the IRSST, to perform more in-depth analyses of employment and OHS among young people entering the labour market. The IRSST's exceptional contribution to ÉLDEQ was in fact underscored at Acfas' 84th Congress in 2016.

Other collaborative activities pursue strategic objectives, particularly in terms of training the next generation of OHS researchers and scientists. Examples include the

funding agreements in place with the CIHR (research chair in gender, work and health) and the three Fonds de recherche du Québec (OHS career scholarships).

Over the years, the Institute has strengthened its ties with several Québec and Canadian partners, while also establishing business relationships with research centres elsewhere in North America and in Europe. Such partnerships are expected to continue in the years ahead, be they with the INRS in France, HSE in the United Kingdom, IFA in Germany, or NIOSH in the United States. Specific multilateral agreements are on the horizon for 2018-2022, particularly regarding the development of measurement systems for musculoskeletal problems and machine safety.

In addition to maintaining such agreements, new ones are constantly being established in order to consolidate the IRSST's position in occupational health and safety research. The signing of a framework partnership agreement with the Occupational Cancer Research Centre (OCRC) in 2017 reflects this desire to collaborate with well-established, highly credible organizations, and in turn, creates a spirit of healthy competition among researchers and facilitates networking. The materialization of specific agreements with Asian research centres is another possibility to be assessed.

The partnership agreements that will continue or begin during the 2018-2022 period will give the Institute an opportunity to carry out more complex or larger-scale studies, especially with regard to emerging problems. Some of these collaborative efforts will place considerable importance on transferring new knowledge. In all cases, the decision to renew or initiate partnerships will depend on the real added value they represent in terms of increasing OHS research capacity and reaping potential benefits for Québec workplaces.





# 8. SCIENTIFIC RECOGNITION

The fact that the IRSST is recognized for the scientific expertise of its personnel and the calibre and originality of its research and laboratory activities facilitates strategic networking. For example, the Institute is a member of the Sheffield Group, which brings together the heads of the world's leading OHS research centres. The Institute

also networks by sitting on various standardization committees and helping organize major national and international scientific events with themes conducive to promoting IRSST-conducted or -funded research. Each of these actions reinforces the Institute's position as a vital organization in the world of OHS research.

## 8.1 INVOLVEMENT IN COLLOQUIA

Here at home, the IRSST has promoted the advancement of OHS knowledge by holding an annual institutional colloquium, beginning in 2006. This event provides the opportunity for the Québec research community and the Institute's partners to discuss research issues, emerging problems, and unifying topics. During the new five-year cycle, the Institute will continue to organize such local events, including some specifically on the transfer and uptake of research results, knowing that by doing so, it reaffirms its leadership in Québec.

In the same vein, the Institute will assume its leadership role through its continued involvement in organizing major events. During the previous cycle, it helped organize the 21st International Congress on Acoustics, as well as the 2016 conference of the Canadian Association for Research on Work and Health (CARWH), and held two symposia at the 45th annual conference of the Association of Canadian Ergonomists. The Institute also participated in numerous international scientific committees (9th International Conference on the Safety of Industrial Automated Systems [SIAS], the International Conference on Chemical Risk – Innovative Methods and Techniques (2015) of the INRS-France, the 51st Congress of the Société d'ergonomie de langue française [SELF], and the 4th International Conference on Industrial Risk Engineering (CIRI 2014)). In addition, it hosted four standardization committees

(ISO/TC 108/SC 4 on Human exposure to mechanical vibration and shock, ISO/TC 146/SC 2 WG 7 on Silica, CAN/CSA Z94.4-11 on the Selection, use and care of respirators, and CAN/CSA Z259 on Fall protection). Lastly, the Montréal Symposium on Occupational Carcinogens held at the IRSST in April 2017 provided an opportunity to illustrate the Institute's contribution to the production and transfer of knowledge on the human and economic burden of occupational cancers.

Depending on the circumstances that arise during the new five-year cycle, the IRSST intends to continue its involvement in organizing important scientific events that will ensure recognition of its leadership role in research. One such action takes the form of an agreement between the IRSST and the Société du Palais des congrès de Montréal, which made the joint decision to coordinate their resources to attract major scientific OHS-related events to Montréal. This partnership will allow the Institute's scientists and its many external research collaborators to extend their reach on the local, national, and international stages, while also better publicizing the IRSST's role and influence. Starting in 2018, a joint IRSST/Ambassadors' Club Joint Award will be given out to reward researchers who help attract international conferences to Montréal and the Palais des congrès.

## 8.2 PARTICIPATION IN PRESTIGIOUS COMMITTEES

The IRSST helps improve standards and influences regulations on occupational injury prevention by facilitating the ongoing participation of its scientists in expert and standardization committees. In 2016, 11 national or international standardization committees (e.g. ISO, ASTM, and CSA Group) included at least one of the Institute's scientists. During the 2018-2022 cycle, this staff participation in such committees and in committees of the CNESST and its network (including regulatory committees) is expected to continue.

The IRSST has also been a member of the International Commission on Occupational Health (ICOH/CIST) for a number of years. Some of its staff and members of its

external researcher network take part in the activities and conferences of the ICOH's scientific committees.

Moreover, IRSST personnel are invited to participate in the activities of committees or working groups that report to government authorities here and elsewhere around the world. Whether in an advisory role at Singapore's Workplace Safety and Health Institute, a reference role at ANSES (France) and the Occupational Cancer Research Centre (Ontario), or an expert role at the ICOH/CIST regarding the prevention of the risks associated with nanoparticles, the IRSST makes its presence known and influence felt in arenas where it is important to promote its research findings on subjects of common interest.

## 8.3 WHO COLLABORATING CENTRE

Since March 2013, the IRSST's Scientific Division has been part of the global network of World Health Organization (WHO) collaborating centres for occupational health. During the 2013-2017 cycle, the Institute's contribution concerned characterization, handling, and exposure control activities, and best practices for the safe use of nanoparticles. The WHO designation was renewed in March 2017 for another four years, with no fewer than seven different activities on the agenda:

- characterization, best practices, and control of worker exposure to chemical and carcinogenic substances;
- advancement of knowledge related to climate change and its consequences on worker health and safety

from a sustainable development perspective, and of knowledge related to the risks associated with green jobs; and

- assessment of the economic burden associated with occupational injuries.

In addition to granting the Institute a prominent role, the Collaborating Centre status constitutes another form of recognition of the calibre of work done by the Institute and its personnel. This allows it to, among other things, share its expertise with all Member States of the WHO and promote the dissemination of knowledge to all preventionists wishing to adopt an evidence-based approach.

## 8.4 INSTITUTIONAL EVALUATION

The IRSST has submitted itself to a recurrent practice of institutional evaluation (three times in the past decade). A committee of independent experts has assessed its achievements for the 1999-2004, 2006-2010, and 2011-2015 periods respectively. Convinced of the value

of this process, the Institute intends to continue the practice, the results of which provide a critical view of its leadership and its capacity to achieve its mission notably by developing scientific knowledge that meets the needs expressed by its partners.

# 9. LABORATORY SERVICES AND EXPERTISE

As part of the service agreement between the CNESST and the IRSST, the Institute provides the Commission and its network with the laboratory services it needs to implement the prevention activities prescribed under the Québec government's occupational health and safety plan. Occasionally, it performs certain laboratory analyses requested by professionals outside the network.

The Laboratory Division contributes to research in addition to responding to requests for analyses from the CNESST and OHS professionals as a whole.



## 9.1 ACCREDITATIONS AND CERTIFICATIONS

For the IRSST, certifications serve as a guarantee of the quality, integrity, and recognition of the work performed in its laboratories. Currently, the laboratories hold national and international certifications from the American Industrial Hygiene Association – Laboratory Accreditation Programs (AIHA LAP), the Calibration Laboratory Assessment Service (CLAS) of Canada's National Research Council (NRC), and the Centre d'expertise en analyse environnementale du Québec (CEAEQ). The IRSST also has approval for blood lead proficiency testing from the Occupational Safety and Health Administration (OSHA) in the United States. It should be noted that the Institute's Laboratory Division remains the only Canadian holder of certification for acoustical calibration (CLAS-NRC).

The IRSST's Laboratory Division had the AIHA-LAP and CLAS-NRC certifications for its calibration laboratories renewed during the 2013-2017 five-year cycle. New methods were also added in these two certification areas and are presented in Section 8.3. Moreover, in 2014, the CEAEQ accredited the IRSST's laboratories for microbiological *legionella* analyses. Regarding quality assurance, work on the application for ISO 17043 accreditation should wind up during the 2018-2022 cycle. This new accreditation will help support the development of asbestos and isocyanate proficiency testing programs.

During the new cycle, the laboratories also hope to obtain accreditation under the Environmental Laboratory Approval Program (ELAP) 198.4 of the New York State Department



of Health, Wadsworth Center, for the transmission electron microscopy (TEM) analysis of asbestos in non-friable, organically-bound building materials.

Processes will continue during the 2018-2022 five-year cycle to ensure maintenance of the certifications and accreditations already held.

## 9.2 ANALYSES AND ACTIVITIES FOR THE OHS NETWORK

During the 2011-2015 period, the average number of laboratory analyses performed annually stood at 70,485, representing an increase of approximately 5,000 analyses over the 2009-2011 period.

The average annual number of hours spent calibrating, repairing, and maintaining direct measurement and sampling instruments was 8,233, representing an increase of roughly 6% over the preceding period. This increase is attributable to an agreement with a new IRSST client, namely, Labour Canada (now Employment and Social Development Canada or ESDC), and the addition of machines to the IRSST's instrument bank. All requests for calibration and conformity assessment, which come mainly from partners in the prevention-inspection network, will continue to be processed with diligence during the new cycle. This will be facilitated by the recent hiring of an industrial hygienist, who will ensure optimal management of the IRSST-administered inventory of the 7,000 direct-reading instruments and provide tactical expertise in industrial hygiene to support internal and external partners. This new resource will also assess the possibility of implementing an ISO standard in his area of activity.

As well as providing professionals in Québec's occupational health and safety network with priority service regarding environmental, microbiological, and toxicological analyses, the IRSST's laboratories offer their services to professionals outside the network who wish to do business with the Institute. These contracts generate additional revenues that go toward hiring staff, purchasing new instruments used in routine service activities, and maintaining the Quality Control Program for Fibre Counting.

In 2016, the IRSST's laboratories rolled out a new Laboratory Information Management System (LIMS) to ensure analysis follow-up. This new LIMS allows all partners to submit their samples and receive their results via the Internet. It boosts productivity and reduces turnaround time for producing analysis results, as well as facilitating certain equipment loan services by means of electronic transactions. During the new cycle, the laboratories will continue their efforts to enhance the LIMS to ensure analysis follow-up in compliance with the various accreditation and certification programs.

Ever intent on continuously improving its services, the Laboratory Division conducts frequent client surveys. Over 80% of the respondents to the last survey in spring

2015 indicated their satisfaction with the time it takes to receive analysis results and with the various instruments and equipment calibrated. Over 90% of the respondents expressed a high level of satisfaction with the quality of the service received and of the analysis report (presentation and intelligibility of the content).

At the CNESST's request, the IRSST's laboratories are continuing to offer their support in matters requiring scientific expert assessments of problems encountered in various workplaces or associated with regulatory changes.

## 9.3 DEVELOPMENT AND VALIDATION OF ANALYTICAL METHODS

One of the roles of the IRSST's laboratories is to develop and validate new analytical and instrument-calibration methods. Various factors can influence how they establish development priorities. For example, amendments to the *Regulation respecting occupational health and safety* or to the *Safety Code for the Construction Industry* may translate into the adaptation of the Institute's analytical services to ensure compliance with the new standards. The introduction of new substances may necessitate the development or implementation of new analytical methods. The need to revise and develop new methods may also result in discussions with various ISO and ASTM committees in which the laboratories' scientific professionals participate. Furthermore, close attention is paid to all analytical developments to obtain irrefutably high-quality results, and ultimately, to optimize productivity.

Since 2012, the development of a dozen or so new methods has led to the addition of new services. These new methods include:

- Method for measuring 4,4'-diisocyanate diphenylmethane (MDI) aerosols on an ASSET EZ4-NCO tube;
- Method for measuring respirable combustible dust (previous *Regulation respecting occupational health and safety in mines*);
- Method for measuring total carbon (clone of NIOSH 5040);
- Method for measuring asphalt fumes (total organic matter – clone of INRS M-2);
- Method for measuring urinary S-phenylmercapturic acid (benzene BEI);
- Method for measuring s-HAP: benzo(b, j, k) fluoranthenes;
- Method for measuring gases by gas phase chromatography (GPC) for respirable compressed air (CRA);
- Method for measuring mandelic acid and urinary

phenylglyoxylic acid (LC/MS transfer);

- Method for measuring urinary o-, m-, p-methylhippuric acid (LC/MS transfer);
- Method for measuring hexavalent chromium;
- Method for measuring subtilisin; and
- Detection and counting of *Legionella pneumophila* and *Legionella sp.* using molecular biology methods (PCR assay).

Nine new analytical developments are anticipated over the 2018-2022 five-year cycle:

- Method for measuring 12 aldehydes in the air by LC/MS;
- Method for measuring 4,4'-methylene dianiline (MDA) in the air by LC/MS;
- Addition of compounds in the amino family to existing IRSST method 363 (amines by LC/MS);
- Method for measuring organic volatile compounds on thermal desorption tubes by GC-MS;
- Method for measuring isocyanate metabolites by LC/MS for biological monitoring purposes;
- Method for measuring urinary arsenic for biological monitoring purposes;
- Method for measuring metals on a Solu-Sert sampling substrate;
- Method for measuring asbestos in floor tiles by TEM;
- Development of a new calibration station for sound level meters in compliance with standard IEC 61672-1:2013, 61672-2:2013, and 61672-3:2013.

In addition, to support the various OHS professionals in applying the *Safety Code for the Construction Industry* with regard to asbestos-contaminated soils, the laboratories' team will produce a document explaining the sampling and sample preparation processes, and how these materials are analyzed.

## 9.4 CONTRIBUTION TO RESEARCH

The Laboratory Division contributes to research by developing specific analytical methods for projects carried out by researchers or scientific professionals from the Chemical and Biological Hazard Prevention field to evaluate worker exposure mainly to chemical or microbiological contaminants. The laboratories also take part in generating scientific knowledge in their respective field by developing their own projects and hosting graduate students. Some of the projects that will be carried out during the 2018-2022 period include:

- Implementation of a method for measuring methylene dianiline (MDA) in workers' urine
- Implementation of a method for measuring methylene dianiline (MDA) in the air and in soils
- Comparison of various samplers used for measuring isocyanate vapours.



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