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Use of multiple data sources for surveillance of work-related chronic low-back pain and disc-related sciatica in a French region

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Key words: epidemiological surveillance, prevention index, low back pain, disc-related sciatica, industry sector

Abstract

Objective. To compare the data of the French workers' compensation system (WCS) and three surveillance networks, and to determine the possibility of identifying the industry sectors most in need of programs for prevention of low back pain (LBP).

Methods. This study compared four databases and two types of indicators in a west central region of France:

- surveillance of musculoskeletal symptoms in the working population (LBP and disc-related sciatica (DRS) indicators; Cosali study)
- surveillance of uncompensated work-related diseases (LBP and DRS indicators)
- surveillance of lumbar disc surgery (LDS) in the general population (DRS indicator)
- French WCS (disc herniation with radiculopathy caused by vibration or handling of materials; DRS indicator)

People aged 20-59 were studied. The prevention index (PI) was used to rank industry sectors according to the number of cases and the prevalence/incidence rate.

Results. Construction and manufacturing were the first sectors in terms of PI for men in all databases and indicators. Moreover, transport and agriculture were not consistently highlighted. For women, manufacturing was the leading sector (except for the LDS study: health sector), followed by the health sector. Specific epidemiologic surveillance networks (LDS and Cosali studies) provided ranking of the greatest number of sectors out of the 17 classified. For DRS indicators, the LDS study classified 13 sectors for both genders, and for LBP indicators, the Cosali study ranked 8 and 7 sectors in men and women, respectively.

Discussion. The results showed the complementarity of the four surveillance programs. A multi-component surveillance system allowed detection of industry sectors most in need of prevention programs.

Introduction

Low back pain (LBP) is the leading cause of musculoskeletal morbidity in the workplace (Inserm, 2000). Almost 50% of European workers report suffering from back pain (Eurofound, 2012), and LBP is among the top six health problems in terms of costs for society (Dagenais et al., 2008) and one of the three most disabling types of pain in developed countries (Lamb et al., 2010). LBP causes considerable human and social costs in terms of pain and discomfort in the workplace and everyday life (Punnett et al., 2005; Burton et al., 2006) and in terms of health related quality of life (Yamada et al., 2013). In addition to the intensity of the pain, the severity of LBP is mainly due to the disability it causes (Loisel et al., 2002). It generates substantial direct costs associated with seeking medical and paramedical care and diagnostic procedures (Walker et al., 2003; Ritzwoller et al., 2006; Becker et al., 2010) and especially indirect costs (compensation, job loss, etc.) which are at least 5-6 times higher.

In France, chronic LBP with disc herniation with radiculopathy caused by vibration or manual handling of loads is the only work-related LBP in Tables of occupational diseases (OD) recognized by the workers' compensation system since 1999 (Roquelaure et al., 2005; INRS, 2016). The restrictive recognition criteria in terms of diagnosis and occupational exposure have meant that the workers' compensation system is known to provide an underestimation of the extent of the phenomenon of LBP at work (Rivière et al., 2014; Stock et al., 2014). For several years, the only source of information available in France to describe the current increasing number of musculoskeletal disorders (MSDs) has been workers' compensation claims. Santé publique France, the French national public health agency, therefore implemented a pilot, multi-component epidemiological surveillance system for work-related MSDs in the Pays de la Loire region in 2002 (Ha et al., 2009; Fouquet et al., 2010; Roquelaure et al., 2011). This program combined three main components: 1) epidemiological surveillance of sentinel health events in the general population (disc-related sciatica (DRS) as the sentinel event for LBP) (Roquelaure et al., 2011; Fouquet et al., 2016); 2) epidemiological surveillance of the main MSDs (including LBP) and their risk factors in the workplace (Ha et al., 2009; Serazin et al., 2013); and 3) registration of uncompensated work-related diseases (UWRD)

related to LBP and DRS (Rivière et al., 2014). However, a such multi-component surveillance system is difficult to implement and to maintain in the long term and requires human and financial resources. It is therefore necessary to consider the contribution of the different components with the aim of detecting industry sectors most in need of programs for prevention of LBP.

A sentinel occupational health event was defined by Rutstein et al (Rutstein et al., 1983) as "a disease, disability, or untimely death which is occupationally related and whose occurrence may: 1) provide the impetus for epidemiologic or industrial hygiene studies; or 2) serve as a warning signal that material substitution, engineering control, personal protection, or medical care may be required". The choice of indicator that may best represent the extent of LBP is complex because of its high prevalence in the general population, the high variability depending on the indicator used (reported pain, surgical data, compensation data, etc.) and the absence of a standardized clinical diagnosis.

The aim of this study was to compare the different results of the surveillance network components and the data of the French workers' compensation system and to determine the possibility of identifying the industry sectors most at risk of chronic LBP and DRS.

Materials and Methods

Databases; population sources and indicators

The pilot three-component surveillance program for MSDs was set up in the Pays de la Loire region (Loire valley area, west central France, 3,305,000 inhabitants and 1,247,839 salaried workers) in 2002 (Ha et al., 2009). According to the French National Institute of Statistics and Economic Studies (INSEE) census of 1999, this region contained 5.5% of the French population and 5.6% of the French workforce. Its socioeconomic structure is diversified and close to that of France as a whole.

Two types of indicators were used in this study: one concerning chronic LBP and the second concerning DRS (included in the chronic LBP indicator).

This article compares four data sources (Table I), i.e. the data of the three components of the pilot surveillance system for MSDs and the regional data of the French workers' compensation system:

1. *Cosali study*: This component was designed to assess the prevalence of musculoskeletal symptoms in the working population and their personal and occupational risk factors (Serazin et al., 2013). Between 2002 and 2005, 83 occupational physicians (OPs) randomly selected workers from the overall population of salaried workers between the ages of 20 and 59 working in a private or public company in the Pays de la Loire region. A total of 3,710 workers, with or without MSD, for whom medical surveillance was provided by an OP participating in the network, were included in the study, regardless of their type of job contract.

   All workers for whom an address was available received a self-administered follow-up questionnaire by mail between 2007 and 2009 (response rate=67.1% among contactable subjects, (Serazin et al., 2013)). All workers aged between 20 and 59 at follow-up and who completed the follow-up questionnaire were then studied. Musculoskeletal symptoms (acute or chronic pain) were collected using the Nordic questionnaire (Kuorinka et al., 1987). Workers with chronic **LBP** were

defined as those having experienced any aching, discomfort, pain or numbness for more than 30 days or permanently in the lower back during the preceding 12 months (Table II). Workers with **DRS** were defined as those suffering from chronic LBP with declared sciatic pain, with pain extending to the lower limb (whether below the knee or not).

2. *UWRD surveillance*: Epidemiological surveillance of uncompensated work-related diseases (UWRD) related to MSDs. The objectives of this second level of surveillance were to assess the prevalence of MSDs that could be recognized as an OD according to the OP, to identify emerging pathologies of the musculoskeletal system notified as work-related by the OP, and to evaluate the underreporting of MSDs in OD. Initially included in the network of the Pays de la Loire region, this program has since 2005 been extended to 15 out of the 22 French regions (Valenty et al., 2015). Most workers in France undergo a regular mandatory health examination (every two years in 2008-2010). Each year a volunteer network of OPs record all UWRDs seen during twice-yearly 2-week periods selected as 'UWRD Fortnights'. The fortnight dates change annually and differ in each region. UWRDs are defined as every symptom or disease that the OP considers to be work-related, which are not receiving compensation from social security at the time of the OP's examination. Occupational disease claims that have been filed but a decision has not yet been reached, those that have been rejected by social security and OD which characteristics don't fill requirements of OD recognition tables are deemed to be UWRDs. All workers with **LBP** and **DRS** among all the salaried workers seen by OPs during the 2-week period under consideration were counted as cases of LBP and DRS, respectively. Each OP also completed a form with the total number of workers seen during the period, to serve as the denominator for calculating UWRD prevalence rates. As for the Cosali study (see above), the UWRD-DRS indicator is a part of the UWRD-LBP indicator. The definition of UWRD-LBP and UWRD-DRS indicators is detailed in Table II and in the Appendix. All UWRDs notified for workers aged between 20 and 59 and working in the Pays de la Loire region in 2008-2010 were studied. In the Pays de la Loire region in 2008-2010, between 21% and 37% of the regional OP's participated in the fortnight on a voluntary basis (Sérazin et al., 2012). In

2008-2009, the representativeness of the industry sectors monitored by these OP's throughout the year was proportionate for agriculture and industry (Sérazin et al., 2011). However, in 2010, three sectors were over-represented: agriculture, forestry and fishing; mining, manufacturing and other industries; and wholesale and retail trade (Sérazin et al., 2012). On the other hand, the sectors of public administration, education, and human health and social action were under-represented.

3. *LDS study*: This component was designed to estimate the incidence of lumbar disc surgery (LDS), chosen as the sentinel event for DRS and generally for LBP, in the general population, and to assess the proportion of LDS attributable to occupational activity. Epidemiological surveillance of LDS in the general population was set up at centers for spinal surgery in the Pays de la Loire region, using seven codes for surgical acts selected in collaboration with spinal surgeons (Roquelaure et al., 2011; Fouquet et al., 2016). The hospital admissions of subjects who had undergone surgery for DRS during the study period were extracted from the French public and private hospital database. Patients were included if they were aged between 20 and 64 years, lived in the region and had undergone their first lumbar disc surgery between 2007 and 2008 in the participating centers. A self-administered questionnaire was sent to collect medical and surgical history and employment history. The centers' databases identified a sample comprising 3,150 patients, of whom 1,670 were included in the study (Fouquet et al., 2016). All inpatients aged between 20 and 59 were therefore studied to compare other data sources. This study provides only a **DRS** indicator (more details in Table II).
4. *OD-DRS*: This fourth system was used to analyze the workers' compensation (WC) for OD. Analysis of these data allowed the incidence of compensated MSDs to be calculated. In France, the WC system for OD is based on a series of Tables, themselves based on presumption of causality, which define the required criteria for compensation by social insurance funds. A disease is recognized as occupational and compensated if all the criteria in the corresponding Table are met: i.e. diagnostic criteria, time since the most recent exposure and conditions of the exposure. The diseases detailed in these Tables are all compensable OD; about 100 are listed in the general

national health insurance system and about 50 in the agricultural health insurance system (INRS, 2016). Only chronic LBP associated to disc herniation with radiculopathy (M511, code according to the 10th revision of the International Classification of Diseases) caused by vibration or manual handling of loads are included as back pain in Tables of the WC system. This study provides only a **DRS** indicator (more details in Table II). Only workers compensated for OD-DRS living in the Pays de la Loire study were included.

For each data source, each industry sector was coded using the 17 sections of the French version of the statistical classification of economic activities in the European Community (Nomenclature d'Activités Française [NAF] codes of 2003).

Statistical analysis

Concerning the Cosali study and the UWRD surveillance, the prevalence rate was calculated using the number of cases of chronic LBP and DRS as numerator and the whole salaried staff included in each system as denominator (Table I). For the LDS study and the OD-DRS, the incidence rate was computed using the number of DRS cases in each system as numerator and the number of employed people according to INSEE census of 2007 as denominator.

The prevention index (PI) combines two types of ranking information: the frequency and the rate of incidence or prevalence (Silverstein et al., 2002). Ranking was determined according to the industry sector with the highest rate of incidence or prevalence (ranked 1) down to the sector with the lowest rate of incidence or prevalence (last ranking equal to the number of sectors considered). The ranking of the absolute frequencies of OD (i.e. ranking of the number of cases) observed was applied in the same way. Using the information on the frequencies and the rate of incidence or prevalence, the PI can be calculated as the mean of two ranks (see formula below):

$$PI = \frac{\text{Incidence/prevalence rate ranking } + \text{Frequency ranking}}{2}$$

A crude rate ratio of incidence or prevalence was calculated, dividing the rate of incidence or prevalence for each sector studied by the rate of incidence or prevalence computed for all people for which the sector was notified (Silverstein et al., 2002). Where two PI rankings were equal, the higher rate ratio was used to define the first PI ranking. The highest PI (PI rank=1) allowed detection of the industry sectors with both the greatest burden and the greatest risk of LBP or DRS and which should be prioritized in targeting research and prevention.

For statistical reasons, only sectors with more than five cases are presented in the analysis.

Statistical analyses were performed using SAS 9.4 and Microsoft Excel 2010.

Ethics approval was provided by the French National Committee for Data Protection (CNIL).

Results

In the 17 sector divisions, construction, manufacturing, transportation and agriculture had the highest PIs for men (Table III). Construction was the main sector for the two indicators (chronic LBP and DRS) in terms of PI for all sources, except for the Cosali study. Construction also presented a rate ratio higher than 1 for all studies and indicators (varying between 1.17 and 2.86). The manufacturing industry also appeared to be a priority sector for both indicators, except according to the LDS study (PI ranking=4 and Rate ratio<1). Transportation was also associated with high PI according to the Cosali and the LDS studies (rate ratio between 1.38 and 1.44) and agriculture according to UWRD surveillance and OD-DRS (rate ratio between 1.95 and 2.48). Public administration and defense was associated with high PI in the LDS study, and real estate, renting and business services in the Cosali study (for DRS indicator only).

For women, the manufacturing industry was the leading sector in terms of PI for both indicators (Table IV), except for the LDS study (PI ranking=6 and Rate ratio<1). The human health and social work activities sector presented high PI for all studies for both indicators. The rate ratio was higher than 1 (between 1.16 and 1.63) for all indicators, except for chronic LBP in the Cosali study. The next sector for all indicators in terms of PI was wholesale and retail trade according to the UWRD surveillance and OD-DRS, whereas it was public administration according to the Cosali study, and transportation and communication sector and accommodation, and food service activities according to the LDS study.

MSDs specific epidemiologic studies were the data sources which allowed ranking of the greatest number of sectors. The LDS study allowed to classify 13 of 17 industry sectors for DRS indicators for both sexes and the Cosali study allowed to rank 8 and 7 sectors for LBP indicators for men and women, respectively. OD-DRS allowed ranking of a smaller number of sectors (7 for men and 5 for women) than other data sources. However, it did not require specific data collection and its results were comparable with other data sources.

Discussion and conclusions

Using four independent population-based data sources on the frequency of work-related chronic LBP and disc-related sciatica, this study detected sectors most in need of prevention, i.e. construction, manufacturing, transportation and agriculture sectors for men and manufacturing, human health and social work activities, wholesale and retail trade and public administration sectors for women.

This study showed complementarity between all data sources. The independence, the quality and the contemporary nature of the four data sources used for the comparison of the burden of chronic LBP and DRS between activity sectors are the key strengths of this study. Nevertheless, certain limitations need to be taken into consideration when interpreting the results (Table I). Indeed, some differences could be explained by the differences in studied populations of the data sources. Salaried workers provided the population for two data sources (Cosali study and UWRD surveillance) because these studies needed the participation of OPs. Almost all salaried workers in France (including temporary and part-time workers) undergo a regularly-scheduled mandatory health examination (every two years in 2008-2010), whether they have health problems or not. All salaried workers and farmers were included in the OD surveillance population. The LDS study population was the largest used in this article since all employed individuals (salaried and self-employed people) and unemployed individuals were included in this study. Moreover, the number of cases allowed us to compute PI only for aggregated sectors, which is a limitation for targeting sectors requiring prevention programs. Implementing a multi-component epidemiological surveillance system can thus fill in the gaps left by each of the four individual systems.

A key point for discussion is the choice of the indicator to be used for the epidemiological surveillance of work-related LBP. Whereas Rutstein et al. defined clearly what an occupational sentinel health event is (Rutstein et al., 1983), the choice of the indicator that may best represent the extent of LBP is complex because of its high prevalence in the general population, the high variability depending on the indicator used (reported pain, surgical data, compensation data, etc.) and the absence of a standardized clinical

diagnosis. Two types of indicator were therefore used in this study, i.e. chronic LBP (more than 30 days of pain within the last 12 months) and DRS. In addition to the indicator used for chronic LBP, we chose the most restrictive indicator (DRS) for two main reasons. First, hospital discharges following lumbar disc surgery performed in specialist spine centers appeared to be the best available sentinel event for the surveillance of DRS, and more generally of LBP, because its incidence is lower than LBP and its estimation is facilitated by the use of using hospital discharge databases (Roquelaure et al., 2011). However, the health care-seeking behavior for LBP of patients may be influenced by their own beliefs and/or those of the healthcare practitioners (Main et al., 2010; Mannion et al., 2013). Undergoing surgery for disc herniation may not only be explained by medical reasons. Thus, a regional study has shown a link between the use of surgery and geographic, socio-economic or related health care system factors (Fouquet, 2016), in line with what has been observed previously in the United States (Andersen and Newman, 2005). In addition, it is important to emphasize that back surgery rates are known to vary between countries and even regions (Rasmussen et al., 2005), possibly due to lack of scientific evidence, financial incentives or disincentives for surgical interventions, differences in clinical training, professional opinion and patients' preferences (Leino-Arjas et al., 2002). It is also possible that manual workers encountered more difficulties in coping with LBP at work, and this may have led to increased use of healthcare and surgical treatment (Leino-Arjas et al., 2002; Kaila-Kangas et al., 2006). Moreover, changes in medical practice have a significant influence on this type of indicators (Joines et al., 2003; Fouquet et al., 2016). Several studies in recent years have shown a similar prognosis in patients who underwent surgery and those who had conservative treatment (cognitive intervention, exercises, etc.) (Peul et al., 2008; Brox et al., 2010). Likewise, medical practice evolves, and surgery is now recommended only in patients with high disability and the most severe cases. The number of surgical lumbar disc interventions has therefore decreased over time and the same trend has not been observed for DRS. Secondly, only DRS is retained to compensate for work-related LBP in France (Roquelaure et al., 2005). LBP and DRS are the leading causes of work incapacity and disability before 45 years of age in France (Inserm, 2000). In view of this social and economic context, two compensation Tables were created by social insurance funds in 1999 in the WC system for OD although they are restricted

to chronic LBP associated with DRS for herniated discs caused by vibrations transmitted to the whole body or by manual handling of heavy loads (INRS, 2016). Although not perfect and not covering isolated LBP, these tables have ranked compensated DRS as the third most common OD in France since 2000, after MSDs of the lower and upper limbs and occupational cancers (Roquelaure et al., 2005). However, the current compensation arrangements fall well short of full compensation. This demonstrates the failure of primary prevention of LBP and the importance of multidisciplinary programs for job retention with LBP, including ergonomic intervention to improve working conditions. At the same time, LBP prevention should be carried out as early as possible in the evolution of LBP (Petit et al., 2015). Therefore, it is necessary to implement a surveillance system to describe all stages of LBP (acute, subacute and chronic), such as the Cosali study (which used the Nordic questionnaire).

In this study, we compared PI rankings, the PI calculation of which requires two types of ranking information, the frequency rank and the incidence/prevalence rate rank. Interpreting the results becomes complicated if classification rankings differ. It is therefore essential to consider the results according to the objectives of the prevention program. If the goal is to reduce the absolute number of cases of LBP, then it would be more appropriate to use the frequency ranking. On the other hand, if the aim is to reduce the risk of LBP, it would be more sensible to use the incidence/prevalence rate ranking. However, from a public health perspective, it is difficult to leave aside one or the other of these two goals in prevention practice and that is why we chose to compare our data using the PI, whose strength is combining frequency and incidence/prevalence rate. In addition, previous studies have shown that PI ranking is more robust than frequency ranking or incidence/prevalence rate ranking (Thiede et al., 2014). Nevertheless, according the same weighting to the frequency ranking and the incidence/prevalence rate ranking (which may appear empirical) might be questioned. It might be possible to assign different weighting to the frequency ranking and the incidence/prevalence rate ranking in the PI calculation according to the aim of prevention campaigns. If the main aim is to reduce the number of cases of LBP, it would therefore be more interesting to give greater weighting in the PI calculation. In this article, we studied large databases, but only with

cross-sectional data and the use of the PI was therefore particularly suitable. Indeed, according to Thiede et al., the strength of the PI is that it can be applied to surveillance data with broad coverage of the working population where there is poor or no information on the healthy working population (Thiede et al., 2014). Finally, as pointed out by Bonauto et al, one of the weaknesses of the PI is that it is calculated from rankings (Bonauto et al., 2006). Converting frequency or incidence/prevalence rate to ranking leads to loss of information. For example, whether the difference between the first and second industry sector be great or small, the difference between the rankings will always be 1. We therefore chose to present rate ratios to allow us to relate sectors to each other. Another weakness of the PI ranking is linked to the number of industry sectors ranked. For example, for the DRS indicator for women, the LDS study allowed ranking of 13 industry sectors whereas only three sectors were ranked by the UWRD surveillance (four by the Cosali study and five by OD-DRS). Thus, although manufacturing was the first sector for three of four studies, this sector was among the firsts in the 13 sectors ranked by the LDS study.

The analyses were performed by stratifying by gender because it is known that risk factors for LBP are different in men and in women (Messing et al., 2009). In our study, sectors with highest PI ranks were different for men and women. This can be explained by the differences in workplace exposure, personal factors and MSDs according to gender (Messing et al., 2009). In contrast to the literature, we chose to present the results according to industry sectors and not according to occupations. Work-based prevention campaigns are indeed usually implemented by industry sector in France. The aim here was to provide the most operational figures to assist the implementation of an effective prevention campaign. This study highlighted sectors with high PI: manufacturing for both sexes; construction, transportation and agriculture for men; and the human health and social work sector and wholesale and retail trade for women. These sectors are often reported in the literature although the analyses are rarely stratified by gender (Murphy and Courtney, 2000; Eurofound, 2012; Miedema et al., 2014). However, many other risk factors for LBP (e.g., specific occupational, psycho-social and organizational factors, individual factors, etc) exist that could not

be studied in this study. Indeed, these risk factors were not reported within the considered surveillance systems. Only the Cosali study was able to capture these (Ramond-Roquin et al., 2015).

Although it has been shown that individual and occupational determinants of LBP vary according to the definition of LBP (Ozguler et al., 2000), our results were similar for all considered data sources and the indicators (LBP or DRS) used. Nevertheless, the results are not fully comparable and a multi-component surveillance system would therefore appear valuable. Moreover, administrative data on compensated OD underestimated the incidence of work-related LBP in our study, as it is commonly observed in other industrialized countries for all work-related MSDs (Stock et al., 2014). The rate of underreporting of LBP was estimated at 63% (range 50-76%) in France by comparing compensated cases and cases identified by the UWRD program (Rivière et al., 2014). Similarly, almost 20% of workers in the LDS study considered their DRS to be an OD with compensation systems and DRS was recognized as an OD for more than 10% of workers (data not shown). This small proportion can be explained by the very restrictive criteria of the Table. Therefore, OD surveillance alone is not enough. Because of the limitations of tables in the WC system (in terms of diagnostic criteria and occupational exposure), only a small proportion of DRS is recognized as OD, which limits the statistical analyses. Moreover, this data source is not exhaustive (75% of the working population). Indeed, for example, self-employed workers and permanent personnel of the public administration and defense systems are not included in this database. This could explain differences between our data sources. The workers' compensation system is therefore not sufficient to describe the frequency of LBP in the working population accurately. On the other hand, OD data do not require specific collection, which encourages us to continue to explore this data source. The UWRD surveillance program, for which the results were comparable to those of the OD surveillance in this study, has been of value in the past (Rivière et al., 2014; Valenty et al., 2015). In addition to demonstrating the under-reporting of LBP, this information has helped to describe time tendencies and to identify sectors in which workers rarely meet the restrictive criteria of the compensation Tables and to monitor disorders or diseases not included in compensation Tables, such as LBP. Finally, findings such as those originating from the Cosali study and

the LDS study document the phenomenon more accurately, because of the large numbers of cases. A surveillance network in the general population seems to be appropriate to describe work-related LBP and sciatica according to categories and sectors more accurately, especially for those which are not covered by the occupational health system (for example farmers, self-employed workers, etc.).These studies are costly in time and money. Fortunately, in France, new epidemiological tools will assist in epidemiological surveillance of LBP in the short-term such as large cohorts, namely “Constances” for the National Health Insurance fund administered by the “Caisse nationale d’assurance maladie des travailleurs salariés” (Zins et al., 2015), “Coset-MSA” for the Agricultural Insurance fund administered by the “Mutualité Sociale Agricole” and “Coset-RSI” for the Self-employed Workers Insurance fund administered by the “Régime social des indépendants” (Santin et al., 2014). These cohorts collect the same data as the Cosali study, i.e. on musculoskeletal pain (acute or chronic), using the Nordic questionnaire, on the main risk factors (personal and occupational) and the entire employment history. Data from the medico-administrative databases are also available. It will therefore be possible at the national level to replace the Cosali study and the LDS study by studies within these cohorts. There are several benefits from these new opportunities. First, the cost of the data collection will be less in terms of time and money. Second, the collected data will be national and therefore representative of the French population. It will originate from the three main social security funds in France (which cover 95% of the working and non-working population (Santin et al., 2014)). To detect the industry sectors most in need of prevention programs at the national level, it should therefore be possible, in the near future, to implement a surveillance program for chronic LBP and DRS based on compensated OD-DRS and previously described in large cohorts. Nevertheless, at a regional level, which is also a level of implementation of health policy in France, it would be necessary to complement this surveillance program with a regional surveillance program for lumbar disc surgery in the general population, because large cohorts will not allow an accurate description of the phenomenon in regions.

To conclude, this study shows the value of a multi-component surveillance system to monitor work-related LBP and thus to detect the industry sectors the most in need of prevention programs.

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Table I. Description of studies included in this analysis in the Pays de la Loire region

Studies	Aims	Number of people aged 20-59 years[a]	Years	Study populations		Reference populations	Strengths	Limitations
Cosali Study	To evaluate the prevalence of: • the musculoskeletal symptoms in the working population • their personal and occupational risk factors	N= 2 028	2007-2009	Survey sample (self-administered questionnaire)	Salaried people working in a company in the region and included in the study in 2002-2005 by the occupational physician and still working in 2007-2009 Regardless of the work contract	Salaried staff (internal denominator)	Use of the French version of the Nordic questionnaire (Ha et al., 2009) Representativeness of the baseline sample (Serazin et al., 2013)	Absence of a standardized clinical procedure by occupational practitioners (Ha et al., 2009) Attrition bias at follow-up (response rate=67.1% among the contactable subjects) with lowest rates among young workers and workers in temporary employment at baseline, particularly exposed to the risk of LBP and DRS Possible underestimation of the prevalence of LBP and DRS, especially those leading to long periods of sickness absence, as in the case of people suffering from chronic LBP
UWRD surveillance	To assess the prevalence of MSDs that could be recognized as an OD, according to the OP To identify emerging pathologies of the musculoskeletal system notified as work-related by the OP To evaluate underreporting of MSDs in OD	N= 46 849	2008-2010	Exhaustive among OP participating voluntarily during the annual fortnights (seen by OP)	Salaried people working in a company in the region Regardless of the work contract and the type of consultation with the OP Judgment on work-relatedness by the OP	Salaried staff (internal denominator)	Expertise of OPs in terms of both the diagnosis and the working conditions for each worker examined Results independent of workers, and of their potential to seek treatment for DRS and to attribute chronic LBP or DRS to occupation	No observation of all UWRD, especially those leading to long periods of sickness absence, as in the case of people suffering from chronic LBP (Valenty et al., 2015) Slight differences between workers followed in the UWRD surveillance program and the national census partly reflect the organization of occupational medicine in France because of differing intervals between health examinations according to occupational risks. (Rivière et al., 2014)
LDS study	To estimate the incidence of LDS, chosen as the sentinel event for DRS and generally for LBP, in the general population To assess the proportion of LDS attributable to occupational activity	n= 1 489	2007-2008	Respondents to a self-administrated questionnaire mailed to all inpatients following lumbar disc surgery in participating private and public hospitals	General population, living in the region Hospitalized for lumbar disc surgery in one of the specialist centers of the region (interventions after failure of first radical treatment excluded)	INSEE census (2007), employed people	93% of regional spine surgery in databases used (Fouquet et al., 2016) No difference between respondents and non-respondents (age, area of residence), except for sex (more women responded)	Non-exhaustive participation (56.8% response rate)
OD-DRS	To calculate the incidence of compensated MSDs, based on the French workers' compensation system for OD	n=917 n=92	2009-2010	Exhaustive for Tables 97 and 98 of the general national health insurance system Exhaustive for Table A057 of the agricultural health insurance system	Salaried people working in a company in the region Recognized OD (but not necessarily compensated for lumbar disc herniation)	INSEE census (2007), employed people	75% of the working population	Certain occupations at high risk of DRS, such as craftsmen and self-employed professions, excluded

[a] N, sample size; n, number of cases.
UWRD, Uncompensated work-related diseases; LDS, Lumbar disc surgery; OD, Occupational diseases; OP, Occupational physician; LBP, Low back pain; DRS, Disc-related sciatica

Table III. Description of indicators among studies included in this analysis in the Pays de la Loire region

Studies	Indicators	Incidence / prevalence
Cosali Study	Statement of worker **Chronic LBP** • LBP during last 12 months: ➢ Over 30 days ➢ Permanently **DRS (included in chronic LBP)** • Among chronic LBP: sciatic pain (reaching the knee or not)	Prevalence (‰) **Chronic LBP** • Men: 220.3 • Women: 212.5 **DRS** • Men: 71.4 • Women: 72.7
UWRD surveillance	Using of CIM-10 codes (see Appendix 1) **Chronic LBP** • LBP without radiation: M5197, M545 (excluding lumbago and acute and subacute LBP), M5490 (only multiple sites with LBP), M5495 • LBP with radiation: M511, M5116, M5117, M512, M5126, M5127, M543 **DRS (included in chronic LBP)** • Chronic LBP with radiation only	Prevalence (‰) **Chronic LBP** • Men: 6.2 • Women: 4.0 **DRS** • Men: 2.4 • Women: 1.3
LDS study	Using codes for surgical acts selected from hospital discharge database (see Appendix 2) **DRS** Seven codes for lumbar disc surgery were selected with spinal surgeons: LHPH907 LFFA002 LFFA003 LFFC002 LFFA011 LFFA010 LHKA900	Incidence (‰) • Men: 0.5 • Women: 0.5
OD-DRS	**DRS** Recognized OD (Tables 97 and 98) **DRS** Recognized OD (Table A057)	Incidence (‰) • Men: 0.5 • Women: 0.2

[a] *N, sample size; n, number of cases.*
UWRD, Uncompensated work-related diseases; LDS, Lumbar disc surgery; OD, Occupational diseases; OP, Occupational physician; LBP, Low back pain; DRS, Disc-related sciatica

Table III. Prevention index rank and rate ratio of chronic low back pain (LBP) and disc-related sciatica (DRS) according to industry sectors for men

a. Chronic low back pain indicator

Industry sectors[a]	Cosali study				UWRD surveillance			
	n	*Rate[b] (‰) [95% CI][c]*	Rate ratio	PI[d] ranking	n	*Rate[b] (‰) [95% CI][c]*	Rate ratio	PI[d] ranking
Agriculture. hunting and forestry	2				**13**	**13.6 [6.2-20.9]**	**1.94**	**2**
Manufacturing	**97**	**234.9 [194.0-275.8]**	**1.02**	**2**	**62**	**8.3 [6.2-10.3]**	**1.19**	**3**
Construction	**22**	**268.3 [172.4-364.2]**	**1.17**	**3**	**34**	**11.3 [7.5-15]**	**1.62**	**1**
Wholesale and retail trade; repair of motor vehicles and household goods	22	215.7 [135.9-295.5]	0.94	6	27	6.9 [4.3-9.5]	0.99	4
Accommodation and food service activities	1				5	8.9 [1.1-16.7]	1.28	5
Transportation and communication	**25**	**316.5 [213.9-419]**	**1.38**	**1**	11	5.5 [2.2-8.7]	0.78	7
Financial activities	6	115.4 [28.5-202.2]	0.50	8	1			
Real estate. renting and business services	21	250.0 [157.4-342.6]	1.09	4	12	2.9 [1.3-4.6]	0.42	8
Public administration and defense; compulsory social security	23	217.0 [138.5-295.5]	0.95	5	6	5.8 [1.2-10.5]	0.83	6
Human health and social work activities	10	222.2 [100.8-343.7]	0.97	7	0			
All non-missing sectors	**236**	**229.3 [203.7-255.0]**			**180**	**7.0 [6.0-8.0]**		

b. Disc-related sciatica indicator

Industry sectors[a]	Cosali study				UWRD surveillance				LDS study				OD-DRS			
	n	*Rate[b] (‰) [95% CI][c]*	Rate ratio	PI[d] ranking	n	*Rate[b] (‰) [95% CI][c]*	Rate ratio	PI[d] ranking	n	*Rate[b] (‰) [95% CI][c]*	Rate ratio	PI[d] ranking	n	*Rate[b] (‰) [95% CI][c]*	Rate ratio	PI[d] ranking
Agriculture. hunting and forestry	0				**6**	**6.3 [1.3-11.2]**	**2.38**	**3**	38	0.4 [0.3-0.5]	0.94	9	**38**	**0.4 [0.3-0.5]**	**1.95**	**3**
Fishing. aquaculture and related service					0				5	1.4 [0.2-2.6]	3.18	8				
Manufacturing	**36**	**90.0 [62.0-118.0]**	**1.14**	**3**	**21**	**2.8 [1.6-4.0]**	**1.06**	**2**	127	0.4 [0.3-0.4]	0.82	4	**71**	**0.2 [0.2-0.3]**	**1.03**	**2**
Electricity. gas and water conditioning supply	0				0				3							
Construction	8	101.3 [34.7-167.8]	1.28	4	**14**	**4.6 [2.2-7.1]**	**1.76**	**1**	**115**	**0.7 [0.5-0.8]**	**1.53**	**1**	**100**	**0.6 [0.5-0.7]**	**2.86**	**1**
Wholesale and retail trade; repair of motor vehicles and household goods	7	71.4 [20.4-122.4]	0.90	5	9	2.3 [0.8-3.8]	0.87	4	67	0.3 [0.3-0.4]	0.82	7	27	0.1 [0.1-0.2]	0.70	4
Accommodation and food service activities	0				1				13	0.4 [0.2-0.5]	0.82	11				
Transportation and communication	**9**	**113.9 [43.9-184.0]**	**1.44**	**1**	5	2.5 [0.3-4.7]	0.94	5	**64**	**0.6 [0.5-0.8]**	**1.41**	**2**	21	0.2 [0.1-0.3]	1.03	5
Financial activities	0				0				21	0.6 [0.4-0.9]	1.53	5	2			
Real estate. renting and business services	**8**	**103.9 [35.7-172.0]**	**1.32**	**2**	5	1.2 [0.2-2.3]	0.46	6	35	0.2 [0.1-0.3]	0.47	12	17	0.1 [0.1-0.1]	0.47	6
Public administration and defense; compulsory social security	6	57.1 [12.7-101.5]	0.72	6	4				**62**	**0.6 [0.5-0.7]**	**1.41**	**3**	2			
Education	0				0				33	0.5 [0.3-0.7]	1.18	10				
Human health and social work activities	4				0				38	0.5 [0.4-0.7]	1.18	6	4			
Collective. social and personal services	1				0				11	0.2 [0.1-0.4]	0.59	13	8	0.2 [0.1-0.3]	0.89	7
All non-missing sectors	**79**	**79.0 [62.3-95.7]**			**68**	**2.6 [2.0-3.3]**			**635**	**0.4 [0.4-0.5]**			**232**	**0.2 [0.1-0.2]**		

[a] Industry sectors coded using the 17 sections of the French version of the statistical classification of economic activities in the European Community (Nomenclature d'Activités Française [NAF] codes of 2003). Results are presented and rate are calculated when there are at least five cases for at least one study (Fishing, aquaculture and related service, Electricity, gas and water conditioning supply, Education and Collective, social and personal services are not presented in table a; Mining and quarrying, Activities of households as employers and Activities of extraterritorial organizations and bodies are not presented in tables a and b); [b] Concerning the Cosali study and the UWRD surveillance, the prevalence rate was calculated using the number of cases of chronic LBP and DRS as numerator and the whole salaried staff included in each system as denominator (Table I). For the LDS study and the OD-DRS, the incidence rate was computed using the number of DRS cases in each system as numerator and the number of employed people according to INSEE census of 2007; [c] 95% confidence interval; [d] Prevention index; In bold, the first three sectors in terms of PI for each study and indicator.

Table IV. Prevention index rank and rate ratio of chronic low back pain (LBP) and disc-related sciatica (DRS) according to industry sectors for women

a. Chronic low back pain indicator

Industry sectors[a]	Cosali study				UWRD surveillance			
	n	*Rate[b] (‰) [95% CI][c]*	Rate ratio	PI[d] ranking	n	*Rate[b] (‰) [95% CI][c]*	Rate ratio	PI[d] ranking
Manufacturing	**62**	**276.8 [218.2-335.4]**	**1.27**	**1**	**20**	**6.5 [3.7-9.3]**	**1.50**	**1**
Wholesale and retail trade; repair of motor vehicles and household goods	16	145.5 [79.6-211.3]	0.66	6	**20**	**6.3 [3.6-9.1]**	**1.46**	**2**
Financial activities	**13**	**276.6 [148.7-404.5]**	**1.27**	**3**	3			
Real estate. renting and business services	14	209.0 [111.6-306.3]	0.96	5	5	1.8 [0.2-3.4]	0.42	4
Public administration and defense; compulsory social security	**23**	**258.4 [167.5-349.4]**	**1.18**	**2**	2			
Human health and social work activities	23	169.1 [106.1-232.1]	0.77	4	**17**	**5.2 [2.7-7.7]**	**1.20**	**3**
Collective. social and personal services	5	156.3 [30.4-282.1]	0.71	7	2			
All non-missing sectors	**172**	**218.3 [189.4-247.1]**			**82**	**4.3 [3.4-5.3]**		

b. Disc-related sciatica indicator

Industry sectors[a]	Cosali study				UWRD surveillance				LDS study				OD-DRS			
	n	*Rate[b] (‰) [95% CI][c]*	Rate ratio	PI[d] ranking	n	*Rate[b] (‰) [95% CI][c]*	Rate ratio	PI[d] ranking	n	*Rate[b] (‰) [95% CI][c]*	Rate ratio	PI[d] ranking	n	*Rate[b] (‰) [95% CI][c]*	Rate ratio	PI[d] ranking
Agriculture. hunting and forestry	1				1				17	0.4 [0.2-0.6]	1.04	7	10	0.2 [0.1-0.4]	3.32	4
Manufacturing	**21**	**97.7 [58-137.4]**	**1.27**	**1**	**7**	**2.3 [0.6-4.0]**	**1.72**	**1**	54	0.3 [0.3-0.4]	0.91	6	**27**	**0.2 [0.1-0.2]**	**2.53**	**1**
Electricity. gas and water conditioning supply					0				1							
Construction	0				0				6	0.3 [0.1-0.5]	0.78	13	1			
Wholesale and retail trade; repair of motor vehicles and household goods	7	64.8 [18.4-111.2]	0.85	4	**5**	**1.6 [0.2-3.0]**	**1.20**	**3**	72	0.4 [0.3-0.5]	1.04	4	**13**	**0.1 [0.0-0.1]**	**1.12**	**3**
Accommodation and food service activities	1				0				**24**	**0.5 [0.3-0.8]**	**1.42**	**3**	2			
Transportation and communication	1				2				**24**	**0.6 [0.3-0.8]**	**1.42**	**2**	1			
Financial activities	3				1				15	0.3 [0.2-0.5]	0.91	10	1			
Real estate. renting and business services	2				0				22	0.2 [0.1-0.2]	0.39	12	6	0.0 [0.0-0.1]	0.64	5
Public administration and defense; compulsory social security	**7**	**79.5 [23-136.1]**	**1.04**	**3**	0				51	0.4 [0.3-0.5]	1.04	5				
Education	1				1				41	0.3 [0.2-0.4]	0.78	8	1			
Human health and social work activities	**12**	**88.9 [40.9-136.9]**	**1.16**	**2**	**7**	**2.2 [0.6-3.7]**	**1.63**	**2**	**159**	**0.5 [0.4-0.6]**	**1.30**	**1**	**26**	**0.1 [0.1-0.1]**	**1.23**	**2**
Collective. social and personal services	3				1				19	0.3 [0.2-0.4]	0.78	11	1			
Activities of households as employers					0				8	0.5 [0.1-0.8]	1.17	9				
All non-missing sectors	**59**	**76.6 [57.8-95.4]**			**25**	**1.3 [0.8-1.8]**			**513**	**0.4 [0.3-0.4]**			**63**	**0.05 [0.04-0.06]**		

[a] Industry sectors coded using the 17 sections of the French version of the statistical classification of economic activities in the European Community (Nomenclature d'Activités Française [NAF] codes of 2003). Results are presented and rate are calculated when there are at least five cases for at least one study (Agriculture, hunting and forestry, Electricity, gas and water conditioning supply, Construction, Accommodation and food service activities, Transportation and communication, Education and Activities of households as employers are not presented in table a; Fishing, aquaculture and related service, Mining and quarrying and Activities of extraterritorial organizations and bodies are not presented in tables a and b); [b] Concerning the Cosali study and the UWRD surveillance, the prevalence rate was calculated using the number of cases of chronic LBP and DRS as numerator and the whole salaried staff included in each system as denominator (Table I). For the LDS study and the OD-DRS, the incidence rate was computed using the number of DRS cases in each system as numerator and the number of employed people according to INSEE census of 2007; [c] 95% confidence interval; [d] Prevention index; In bold, the first three sectors in terms of PI for each study and indicator.