

# BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email [info.bmjopen@bmj.com](mailto:info.bmjopen@bmj.com)

# BMJ Open

## Trends in Occupational Diseases in Finland, 1975–2013

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-024040
Article Type:	Research
Date Submitted by the Author:	29-Jun-2018
Complete List of Authors:	Oksa, Panu; Finnish Institute of Occupational Health Sauni, Riitta; Ministry of Social Affairs and Health, Department for Work and Gender Equality Talola, Nina; University of Tampere Virtanen, Simo; Finnish Institute of Occupational Health, Operations and Project Support Nevalainen, Jaakko; University of Tampere Saalo, Anja; Finnish Institute of Occupational Health Uitti, Jukka; University of Tampere, Faculty of Medicine and Life Sciences
Keywords:	OCCUPATIONAL & INDUSTRIAL MEDICINE, Statistical trend, Occupational diseases register, Register study

SCHOLARONE™  
Manuscripts

Peer Review Only

Manuscript 290618

**Trends in Occupational Diseases in Finland, 1975–2013**

Panu Oksa, MD, PhD

Finnish Institute of Occupational Health, Tampere, Finland

[panu.oksa@ttl.fi](mailto:panu.oksa@ttl.fi)

Riitta Sauni, MD, PhD

Department for Work and Gender Equality Ministry of Social Affairs and Health, Tampere, Finland

[riitta.sauni@stm.fi](mailto:riitta.sauni@stm.fi)

Nina Talola, MSc

Faculty of Medicine and Life Sciences, University of Tampere, Tampere, Finland

[Nina.Talola@uta.fi](mailto:Nina.Talola@uta.fi)

Simo Virtanen, PhD

Operations and Project Support, Finnish Institute of Occupational Health, Helsinki, Finland

[simo.virtanen@ttl.fi](mailto:simo.virtanen@ttl.fi)

Jaakko Nevalainen, PhD, Professor

Health Sciences, Faculty of Social Sciences, University of Tampere, Tampere, Finland

[Jaakko.Nevalainen@uta.fi](mailto:Jaakko.Nevalainen@uta.fi)

Anja Saalo, MSc

Finnish Institute of Occupational Health, Helsinki, Finland

[anja.saalo@gmail.com](mailto:anja.saalo@gmail.com)

Jukka Uitti, MD, Professor

Faculty of Medicine and Life Sciences, University of Tampere, Tampere, Finland

[jukka.uitti@uta.fi](mailto:jukka.uitti@uta.fi)

1  
2  
3  
4 Corresponding author:  
5

6 Panu Oksa MD, PhD  
7

8 Finnish Institute of Occupational Health  
9

10 P.O. Box 486, FI -33101, Tampere, Finland

11 tel. +358 40 544 9415  
12

13 [panu.oksa@ttl.fi](mailto:panu.oksa@ttl.fi)  
14  
15

16  
17 Word count, excluding title page, abstract, acknowledgments, references, figures, and tables: 3,108  
18  
19

### 20 21 22 **Strength and limitation of this study** 23

- 24 • National statistics on occupational diseases and short follow-ups have been published;  
25 however, year-to-year fluctuations make it difficult to discover the real long-term trends. A  
26 follow-up of almost 40 years provides a useful overview of the status of occupational  
27 diseases (ODs).  
28
- 29 • The Finnish surveillance system has been considered as comprehensive. Every physician is  
30 obligated to notify diagnosed and suspected cases of ODs. Because the register is based on  
31 compensation system, the under-reporting is not a major problem.  
32
- 33 • Still, some physicians may neglect to notify occupational diseases. Moreover, not all  
34 physicians have training in occupational medicine, and may thus fail to connect diseases  
35 with working conditions. For these reasons, some occupational diseases may remain neither  
36 diagnosed nor recorded.  
37
- 38 • While statistics come from one country only, questions behind trends are common.  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## INTRODUCTION

According to the World Health Organization, an occupational disease is any disease contracted primarily as the result of an exposure to risk factors arising from work activity. Work-related diseases (WRDs) have multiple causes, and factors in the work environment may play a role – together with other risk factors – in the development or worsening of such diseases. Occupational diseases (ODs) are an important part of WRDs. All WRDs indicate defects in working conditions or the working environment, but only ODs are reported, and their exact numbers are recorded in registries. The number of ODs can be considered an indicator of efficient preventive actions in the workplace.

The European Union's occupational safety and health strategy for 2014–2020 emphasizes the prevention of occupational and other work-related diseases [1]. The Ministry of Social Affairs and Health in Finland has set a goal to further reduce the number of ODs by 10% by 2020 [2]. The reliable statistical data collection of ODs is important to enable evidence-based policy-making. It is equally important to know the factors behind the numbers of ODs. Changes in the incidence of ODs reflect changes in the conditions and processes of workplaces, but also a greater awareness of health risks among workers, employers, and physicians; improved investments by occupational health and safety (OSH) organizations; better education and national preventive campaigns; and changes in legislation. We need to have up-to-date data of ODs, and we must analyse the effects of working conditions, legislation, and, for example, screening campaigns on ODs. Of course, given the wide range of influential factors, it is very difficult to differentiate the effect of each simultaneous factor on OD incidence.

An OD that entitles the sufferer to compensation in accordance with Finnish legislation is a disease caused by any physical factor, chemical substance, or biological agent encountered in the course of work carried out under a contract of employment, in public service or office, or as an agricultural entrepreneur, as prescribed in the Occupational Accidents, Injuries and Diseases Act (459/2015) and the Governmental Decree on the Ordinance on Occupational Diseases (769/2016). The decree contains a list of physical, chemical, and biological factors and the diseases that may be caused by these factors, which are mostly based on epidemiological or clinical evidence. This list is updated from time to time; for example, carpal tunnel syndrome (2003) and retroperitoneal fibrosis caused by asbestos (2015) were added to the list. The list is not exhaustive, however: factors or diseases not on the list can also be suspected and recognized as causing or being an occupational disease if a causal relationship between the exposure and the disease can be proved in an individual case, as in many respiratory and skin allergies determined by provocation or skin tests, for example. The Finnish Register of Occupational Diseases (FROD) enables the follow-up of trends in the incidence of occupational diseases from 1964 onwards.

1  
2  
3 The aim of this study was to investigate trends in the incidence of recognized and suspected cases of  
4 ODs in Finland from 1975 to 2013 – including variations by industry – and to describe and recognize  
5 factors affecting variations in incidence.  
6  
7  
8  
9

## 10 MATERIAL AND METHODS

11  
12 The FROD kept by the Finnish Institute of Occupational Health (FIOH) was established in 1964, and it  
13 was consolidated as a research register by Finnish legislation in 1993. The objectives of the FROD are  
14 to serve as a source of statistics on occupational diseases, and to promote research and preventive  
15 measures in occupational health. Insurance companies send information on occupational diseases  
16 suspected or diagnosed by Finnish physicians to the Finnish Workers' Compensation Center (TVK).  
17 The FROD is compiled from information from the TVK and the Farmers' Social Insurance Institution  
18 (Mela). According to the Act on the Supervision of Labour Protection (44/2006), physicians are  
19 obligated to report cases of ODs and work-related illnesses to the Regional State Administrative  
20 Agencies, which then send forward reports to the FIOH. Information from this source can be used to  
21 augment and improve data in the FROD.  
22  
23  
24  
25  
26  
27

28 The Register's unit of observation is a filed claim of an occupational disease, either recognized or  
29 suspected. Since 2005, the FROD has gathered cases recognized by insurance companies and those  
30 that remain as suspicions of ODs separately. Recognition means that the insurance company has  
31 received sufficient data and decided to officially recognize a person's condition as an occupational  
32 disease in accordance with Finnish legislation. A recorded case (of an OD or its suspicion) contains  
33 detailed information on the timing, the patient's identification data (personal identity number, sex,  
34 age, occupation), information on the employer (field of industry, location of workplace), diagnosis,  
35 and the causes (exposures) and severity of the disease. The FROD is described in more detail in the  
36 report 'Occupational diseases in Finland in 2012' [3].  
37  
38  
39  
40  
41  
42

43 The data for this study consisted of 240,000 recognized and suspected cases of ODs registered in the  
44 FROD between 1975 and 2013. The early years of the FROD (1964–1974) were excluded, as the  
45 number of cases on record was small. For our study, we extracted from the registry all cases and  
46 suspected cases of ODs and their registration year. We obtained the workforce data by field of  
47 industry from sources published by Statistics Finland [4]. Over the years, the field of industry  
48 categories have undergone several changes. The results of the study are presented according to the  
49 latest classification system from 2008 (TOL 2008), which is identical with NACE Rev.2 [5].  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## Statistical methods

The variables presented here are the disease category, industry, and year of registration of the occupational disease or its suspicion. Using annual workforce statistics and cases and suspected cases of occupational diseases, we calculated the incidence of occupational diseases and suspected occupational diseases per 10,000 employees. For identifying longer term time trends, we used a five-year moving average.

To model the incidence of occupational disease trends between 1975 and 2013, we used a Poisson regression model with natural cubic splines using the splines package with the ns function in R statistical software [6]. With the natural cubic spline, we were able to reach detect the peak in incidence that occurred in 1993. We evaluated tested two different models, one with equally spaced knots and one with six predetermined knots. We used the Bayesian information criterion (BIC) to choose the best fitting model, which was the one with six predetermined knots (see Figure 1). The rate ratios (RR) and the 95% confidence intervals (95% CIs) for the incidence of occupational diseases for each industry were calculated using a Poisson regression model with cubic splines.

## Classification of ODs

In the statistics, occupational diseases are classified into the following disease groups according to diagnosis and cause (for a detailed classification see Appendix 5, Section 3).

**Hearing loss** Noise-induced hearing loss refers to the deterioration of hearing due to prolonged exposure to noise or occasionally due to momentary impulse noise.

**Repetitive strain injury of upper limbs** A repetitive strain injury is a musculoskeletal disease caused by non-physiological stress at work (repetitive and monotonous work, unusual working postures). The group includes tenosynovitis, peritendinitis, epicondylitis, bursitis, and mononeuropathy (e.g. carpal tunnel syndrome) of the upper limbs.

**Allergic respiratory diseases** Allergic respiratory diseases include asthma, allergic rhinitis, allergic alveolitis, and chronic laryngitis.

**Skin diseases** Occupational skin diseases are caused by chemical agents or micro-organisms in the work environment; the most significant diseases in this group are irritant contact dermatitis and allergic contact dermatitis.

1  
2  
3 **Asbestos-induced diseases** The group includes all occupational diseases caused by asbestos –  
4 pleural plaques, adhesions and calcifications being the most frequent. Lung cancer and asbestosis  
5 are the most severe diseases in this group.  
6  
7

8 **Others** The group includes, for example, infectious diseases, conjunctivitis, hand-arm vibration  
9 syndrome, and various types of poisoning, including solvent-induced encephalopathy.  
10  
11

## 12 **RESULTS**

13  
14  
15  
16  
17 Altogether, 240,000 cases of suspected and recognized ODs were analysed. Annual average rates  
18 varied from year to year. The total number was 25.0/10,000 employees in 1975 and 20.1/10,000  
19 employees in 2013. From 1975 to 2013, the Finnish workforce increased from 2.1 million to 2.6  
20 million. Figure 2 presents the time trends of different disease groups from 1975 to 2014. The arrows  
21 indicate important incidents/events that have had an influence on incidence rates.  
22  
23  
24

25  
26  
27  
28 Figure 3 presents the rate ratios of ODs in different fields of industry for 1975–2013. The highest rate  
29 ratio was in mining and quarrying (9.87; 95%CI 8.65–11.30) and construction (9.11; 95%CI 7.98–  
30 10.43), when the reference group was financial and insurance activities (RR=1.00).  
31  
32

33  
34  
35 There is a distinct decreasing trend in ODs from 2005 onwards: the average annual change in  
36 incidence was, for example, -9.2% in agriculture, -10.3% in transportation, and -4.7% in construction  
37 (see Table 1).  
38  
39

40  
41 The annual incidence rate of all notified cases declined from 31/10,000 employees in 2005 to  
42 20/10,000 employees in 2013. The reduction in the incidence rate of recognized occupational  
43 diseases is more distinct than that of suspected cases: the annual incidence of recognized cases  
44 declined from 16/10,000 employees to 8/10,000 employees, while the annual incidence of  
45 suspected cases dropped from 16/10,000 employees to 12/10,000 employees. The average annual  
46 decline was greatest in upper limb strain injuries (-11.1%; see Table 2).  
47  
48  
49

50  
51 Table 1. Annual number and average incidence rate (95 % CI) per 10,000 employees, and average  
52 percentage change and 95% confidence interval in incidence of occupational disease in Finland for  
53 2015–2013 by field of industry.  
54  
55  
56  
57  
58  
59



Field of industry	Recognized ODs (2005–2013)		Suspected ODs (2005–2013)	
	Annual average incidence rate (95% CI) per 10,000 employees	Annual average percentage change in incidence (95% CIs)	Annual average incidence rate (95% CI) per 10,000 employees	Annual average percentage change in incidence (95% CIs)
A Agriculture	39.5 (30.8, 48.1)	- 9.2 (-10.2, -8.2)	31.2 (24.5, 37.9)	- 9.8 (-11.0, -8.6)
B Mining	35.4 (29.8, 41.0)	- 4.8 (-8.1, -1.5)	22.2 (18.3, 26.0)	- 10.2 (-4.2, -16.1)
C Manufacturing	26.0 (22.6, 29.3)	- 4.5 (-4.9, -4.1)	24.6 (23.2, 26.0)	- 0.7 (-0.9, -0.5)
F Construction	29.9 (26.4, 33.3)	- 4.7 (-5.4, -4.0)	19.8 (17.6, 22.0)	- 0.3 (-0.5, -0.09)
Others	7.0 (6.0, 7.9)	- 5.7 (-6.2, -5.2)	9.6 (8.9, 10.3.9)	- 2.6 (-3.2, -2.0)
<b>Total</b>	<b>11.7 (9.8, 13.6)</b>	<b>- 6.7 (-7.0, -6.4)</b>	<b>13.5 (12.5, 14.6)</b>	<b>- 2.8 (-3.0, -2.6)</b>

Table 2. Annual number and average incidence rate (95 % CI) per 10,000 employees, and percentage change and 95% confidence interval of recognized and suspected occupational diseases in Finland for 2005–2013.

Occupational disease	Recognized ODs (2005–2013)			Suspected ODs (2005–2013)		
	Number of cases	Annual average incidence rate (95% CI) per 10,000 employees	Annual average percentage change in incidence (95% CIs)	Number of cases	Annual average incidence rate (95% CI) per 10,000 employees	Annual average percentage change in incidence (95% CIs)
Hearing loss	8,299	4.0 (3.2, 4.8)	- 8.1 (-8.7, -7.5)	4,542	2.2 (2.0, 2.4)	1.2 (0.9, 1.5)
Repetitive strain injuries	3,093	1.5 (1.1, 1.9)	- 11.1 (-12.2, -10.0)	4,648	2.2 (1.6, 2.9)	- 13.2 (-14.2, -12.2)
Allergic respiratory diseases	1,896	0.9 (0.7, 1.1)	- 7.8 (-9.0, -6.6)	6,556	3.1 (2.8, 3.5)	2.8 (2.4, 3.2)
Skin diseases	4,295	2.1 (1.7, 2.4)	- 6.5 (-7.2, -5.8)	5,988	2.9 (2.7, 3.0)	-0.1 (-0.2, -0.02)
Asbestos-induced diseases	5,330	2.5 (2.4, 2.7)	- 1.7 (-2.0, -1.4)	1,640	0.8 (0.7, 0.9)	0.0 (0, 0)
Others	1,530	0.7 (0.5, 0.9)	- 11.1 (-12.7, -9.5)	4,752	2.3 (1.6, 2.9)	- 7.9 (-8.7, -7.1)

## DISCUSSION

1  
2  
3 The reliable statistics on ODs offer a solid base for the development of OSH policies and  
4 interventions to prevent work-related illnesses. Our results indicate that there has been a  
5 remarkable year-to-year fluctuation in the incidence of occupational diseases due to various causes;  
6 the analysis of long-term trends is needed to understand the overall direction of the changes.  
7  
8 In-depth analysis of the trends in different branches reveals the areas where more preventive efforts  
9 are needed.  
10  
11

### 12 **1970s**

13  
14  
15 The increase in the incidence of ODs in the 1970s coincided with the establishment of the six  
16 regional offices of the FIOH. The purpose of the regional offices was to support local workplaces and  
17 to educate OSH personnel. This became possible as the FIOH was granted judicial status in the 1970s  
18 and it started to receive annual funding from the state. The first act on FIOH action was passed in  
19 1978 (159/1978).  
20  
21  
22

23  
24 Furthermore, the former voluntary occupational health care system became mandatory in Finland in  
25 1978 (Act 743/1978). The increasing number of professionals in occupational health care is  
26 supposedly related to the increasing number of notifications of ODs, and thus the increasing  
27 incidence of ODs in the register. Gradually, over three years, all private and public organizations with  
28 at least one employee had to arrange occupational health services for their workers. Mandatory  
29 services included, for example, workplace surveys and medical health examinations for workers. The  
30 number of workers covered by occupational health services increased remarkably, from  
31 approximately 1.1 million in 1978 (60% of all employees), to 1.6 million (80%) in 1983, to 1.9 million  
32 (87%) in 2013 [7]. In addition, the number of health examinations increased, revealing more ODs,  
33 which consequently resulted in the increase in the incidence of ODs.  
34  
35  
36  
37  
38  
39

### 40 **1980s**

41  
42 Since 1978, farmers' pension insurance has included mandatory accident insurance (MATA), which  
43 provides compensation for occupational diseases caused by agricultural work. Guidelines for  
44 farmers' occupational health care were provided to municipal health centres in 1984, and farm visits  
45 were fully compensated by the state (Act 859/1984). Several campaigns were launched to encourage  
46 farmers to utilize occupational health care services.  
47  
48  
49

50  
51 The Governmental Decree on the Ordinance on Occupational Diseases contains a list of physical,  
52 chemical, and biological factors and the diseases caused by these factors. Updates to this list have  
53 resulted in the recognition of new ODs. A substantial increase in strain-related upper extremity  
54 musculoskeletal disorders was brought about by the changes in Decree 67/1987. With this decree,  
55  
56  
57  
58  
59

1  
2  
3 epicondylitis and tendinitis of the forearm became compensatory if the condition resulted from  
4 repetitive and one-sided movement or movement that was unfamiliar to the worker.  
5

### 6 **1990s**

7  
8  
9 Screening for asbestos-induced diseases in Finland was carried out from 1990 to 1992 as part of the  
10 FIOH's Asbestos Program. Altogether, 18,900 employees were examined, and 3,500 new  
11 asbestos-related ODs were diagnosed. Most of them were benign pleural changes/plaques, but  
12 there were also 800 cases of asbestosis [8].  
13  
14

15  
16 The founding of a National Centre for Agricultural Health (NCAH) in 1999 was a further push to  
17 develop working conditions in farming and to encourage more farmers to utilize occupational health  
18 care.  
19

### 20 **2000s**

21  
22  
23 From 2003, insurance institutions have sent data on new ODs and suspected ODs to the Workers'  
24 Compensation Center (TVK). The FROD obtains its information from the TVK and the Farmers' Social  
25 Insurance Institution, Mela. Before 2003, insurance institutions sent data directly to the FROD.  
26 Information from Regional State Administrative Agencies (given by physicians) can be used to  
27 complete the data on diseases in the FROD.  
28  
29  
30

31  
32 In Finland, insurance companies pay for the examinations of both suspected and recognized ODs.  
33 The insurance institutions' payment system changed in 2003, however; medical units could claim  
34 examination costs directly from insurance institutions. Prior to 2003, insurance companies paid  
35 yearly a sum of money to the state as compensation for the medical examinations of ODs conducted  
36 at municipal medical centres and hospitals.  
37  
38  
39

40  
41 In Finland, manufacturing, mining and quarrying, construction, agriculture, forestry, and fishing have  
42 clearly had the highest incidence rates of ODs over the decades, although there has been a  
43 decreasing trend since 2005. They are all branches involving manual, physically demanding work,  
44 and several possible occupational exposures are common. Construction work is a good example,  
45 because it includes various health hazards, such as exposure to physical stress, dust, noise, and  
46 vibration. Construction workers have been shown to be at an increased risk of work-related ill health  
47 and injury both in Europe and globally [9]. They have an increased risk of cancer, respiratory  
48 diseases, musculoskeletal disorders, and injuries compared to the general population [10]. The  
49 incidence of skin neoplasia, contact dermatitis, musculoskeletal disorders, mesothelioma, lung  
50 cancer, pneumoconiosis, and other benign pleural diseases is also increased among construction  
51 workers compared to the rest of the working population [11]. The trends of ODs in the construction  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 sector are not decreasing everywhere: significantly increasing trends in noise-induced hearing loss  
4 and work-related contact dermatitis were observed in the construction sector in the Netherlands in  
5 2010–2014 [12]. An examination of trends and patterns in occupational illnesses among construction  
6 workers from 1992 to 2014 in the USA showed that construction workers continue to face a higher  
7 risk of work-related musculoskeletal disorders [13].  
8  
9

10  
11 The Finnish surveillance system has been considered comprehensive [14]. Every physician is  
12 obligated to report diagnosed and suspected cases of ODs. FROD offers data on the incidence of ODs  
13 from 1964 onwards. Because the register is based on a compensation system, under-reporting is not  
14 a major problem. Nevertheless, some physicians may neglect to report occupational diseases.  
15  
16 Moreover, not all physicians are trained in occupational medicine, and some may thus fail to  
17 connect diseases with working conditions. For these reasons, some occupational diseases may  
18 remain either undiagnosed or unrecorded.  
19  
20  
21

22  
23 Registries and occupational diseases differ considerably in various countries in terms of the criteria  
24 for registration and notification, statistical data provided, and legal context [14, 15]. Therefore,  
25 figures on ODs are not necessarily comparable between countries. The ability to compare would be  
26 beneficial for improving occupational health policies and facilitating coordinated research. A  
27 comparison of OD surveillance systems in the EU countries has been recently published in order to  
28 facilitate this work in the future [16].  
29  
30  
31

32  
33 The direct comparison of trends in OD within Europe showed that reports of contact dermatitis and  
34 asthma were declining in most countries, which is consistent with the positive impact of European  
35 initiatives addressing the relevant exposures [17]. This finding is consistent with the results of the  
36 present study, although the largest decline we noted was in the numbers of upper limb  
37 musculoskeletal disorders.  
38  
39  
40

41  
42 The main reasons for the fluctuation of OD incidence rates in Finland include changes in legislation –  
43 such as the addition of new diseases to the list of occupational diseases – screening campaigns, and  
44 developments in technology and occupational safety and health.  
45  
46

47  
48 The decline in the incidence of ODs in 2005–2013 has occurred at the same time as changes in fields  
49 of industry have continued. The number of workplaces in manufacturing has declined as the number  
50 of service workplaces has grown. Some 48.3% of men were employed in manual work in 2005; by  
51 2013, the percentage had dropped to 45.5%. For women, the numbers were 22% and 17.5%,  
52 respectively [18]. These changes influence the annual number and incidence rate of ODs (Table 2),  
53 but the reduction is also true in most other fields of industry (Table 1). Both the number of people  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 leaving the workforce on disability pensions and the frequency of occupational accidents have  
4 decreased. The largest reduction was seen in 2006–2014, when the annual number of new disability  
5 pensions diminished by 26% [19]. The total number of occupational accidents declined by 27% in  
6 2006–2013 [20]. These three phenomena can be seen as a result of enterprises paying more  
7 attention to the improvement of working conditions and occupational health services.  
8  
9

10  
11 There is evidence that technical improvements and innovations in processes may decrease the  
12 number of ODs. For example, passivating chromate by adding iron (II) sulphate to cement markedly  
13 reduced the allergic contact dermatitis incidence among construction workers [20]. In addition, the  
14 end of the practice of using latex gloves resulted in a reduction in allergic contact dermatitis in  
15 health care workers [22, 23]. In the UK, a significant reduction in the incidence of short latency  
16 respiratory disease and asthma attributed to glutaraldehyde or latex coincided with changes in  
17 legislation, mandatory advice from the Medical Devices Agency, new exposure limits, and the  
18 removal of glutaraldehyde-based disinfectants from the market [24, 25].  
19  
20  
21  
22  
23

24 This study provides a useful overview of the status of occupational diseases in Finland over several  
25 decades. These data are a valuable resource for determining which occupations are at an increased  
26 risk and where preventive actions should be targeted. It is important to study the long-term trends  
27 in the statistics of occupational diseases to see the bigger picture beyond the year-to-year  
28 fluctuations.  
29  
30  
31  
32

### 33 **ACKNOWLEDGEMENTS**

34  
35 We wish to thank the many experts at the FIOH for their fruitful comments on this study. In  
36 particular, we wish to express our gratitude to our colleagues at the FROD, especially Lea Palo  
37 (long-term Research Secretary) and Ilpo Mäkinen for their proficiency in maintaining the high quality  
38 and reliability of the Registry.  
39  
40  
41

42 Figure 1. Fitting the cases of occupational diseases and suspected cases of occupational diseases/  
43 10,000 employees for 1975–2013 in the Poisson regression model.  
44  
45

46 Fig. 2 Recognized and suspected occupational diseases in Finland. The five-year moving average  
47 from 1975 to 2013. The arrows indicate important events influencing incidence rates.  
48  
49

50 Fig 3. Rate ratios of recognized and suspected occupational diseases by field of industry in Finland in  
51 1975–2013. The reference group is financial and insurance activities (K), RR=1.00.  
52  
53

### 54 **Statements**

- 55  
56 a. Contributorship statement  
57  
58  
59  
60

1  
2  
3 PO: Primary investigator involved in the study design, study conduct and reporting. RS and JU: Co-  
4 primary investigators involved in the study design, data collecting and reporting. NT and JN: Co-  
5 investigators involved in statistical planning, data processing and reporting. SV and AS: Co-  
6 investigators involved in planning, data collecting, data processing and reporting.  
7  
8

9  
10 b. Competing interests

11  
12 None declared.

13  
14 c. Funding

15  
16 The Finnish Work Environment Fund funded the study (Project number 115142).  
17

18  
19 d. Data sharing statement

20 Information of published data from Finnish Registry of Occupational Diseases is available on website  
21 of Finnish Institute of Occupational Health. No unpublished data are available.  
22

23  
24 e. Patient and Public involvement statement

25 Not required.  
26  
27

28  
29 **REFERENCES**

- 30  
31 1. European Commission. Communication from the commission to the European Parliament, the  
32 Council, the European Economic and Social Committee and the Committee of Regions on an EU  
33 Strategic Framework on Health and Safety at Work 2014-2020. Brussels, 6.6.2014 COM(2014) 332  
34 final.  
35  
36 2. Policies for the work environment and well-being at work until 2020. Publications of the Ministry  
37 of Social Affairs and Health : 2011:14  
38  
39 3. Oksa P, Palo L, Saalo A et al. Occupational diseases in Finland in 2012. New cases of recognized  
40 and suspected occupational diseases. FIOH Helsinki 2014, 79p. [http://urn.fi/URN:ISBN 978-952-261-](http://urn.fi/URN:ISBN 978-952-261-470-4)  
41 [470-4](http://urn.fi/URN:ISBN 978-952-261-470-4) (pdf)  
42  
43 4. Statistics Finland, Population 2005:4. [Suomen Virallinen Tilasto, Väestö 2005:4; Tilastokeskuksen  
44 PX-Web -tietojärjestelmästä, Työssäkäynti, "010 – Väestö alueen pääasiallisen toiminnan,  
45 sukupuolen, iän ja vuoden mukaan"]  
46 [http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin\\_vrm\\_tyokay/010\\_tyokay\\_tau\\_101.px/?rxid](http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin_vrm_tyokay/010_tyokay_tau_101.px/?rxid=e20431bb-9577-4ef1-9a1d-479c299dffe6)  
47 [=e20431bb-9577-4ef1-9a1d-479c299dffe6](http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin_vrm_tyokay/010_tyokay_tau_101.px/?rxid=e20431bb-9577-4ef1-9a1d-479c299dffe6) (accessed 1 Feb 2018)  
48  
49 5. NACE Rev.2 <http://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF>  
50 (accessed 1 Feb 2018)  
51  
52 6. R: A language and environment for statistical computing. R Foundation for Statistical Computing,  
53 Vienna, Austria. URL <http://www.R-project.org/>  
54  
55 7. Annual statistics. The Social Insurance Institution of Finland, Kela Statistics  
56  
57  
58  
59  
60

- 1  
2  
3 8. Koskinen K, Rinne JP, Zitting A, et al. Screening for asbestos-induced diseases in Finland. *Am J Ind Med* 1996;30:241-51.
- 4  
5  
6 9. Watterson A. Global construction health and safety- what works, what does not, and why? *J Occup Environ Health* 2007;13:1-4.
- 7  
8  
9 10. Arndt V, Rothenbacher D, Daniel U, et al. Construction work and risk of occupational disability: a ten year follow up of 14 474 male workers. *Occup Environ Med* 2005;62:559-566.
- 10  
11  
12 11. Stocks SJ, McNamee R, Carder M, et al. The incidence of medically reported work-related ill-health in the UK construction industry. *Occup Environ Med* 2010;67:575-576.
- 13  
14  
15 12. van der Molen HF, de Vries SC, Stocks SJ, et al. Incidence rates of occupational diseases in the Dutch construction sector, 2010-2014. *Occup Environ Med* 2016;73:350-352
- 16  
17  
18 13. Wang X, Dong XS, Choi SD, et al. Work-related musculoskeletal disorders among construction workers in the United States from 1992 to 2014. *Occup Environ Med* 2017;74:374-380.
- 19  
20  
21 14. Spreeuwiers D, de Boer AGEM, Verbeek JHAM, et al. Evaluation of occupational disease surveillance in six EU countries. *Occup Med (Lond)* 2010;60:509-516.
- 22  
23  
24 15. European Commission. Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions. Safer and Healthier Work for All - Modernisation of the EU Occupational Safety and Health Legislation and Policy. COM(2017) 12 Final. Brussels; 2017
- 25  
26  
27  
28 16. Carder M, Bensefa-Colas L, Mattioli S et al. A review of occupational disease surveillance systems in Modernet countries. *Occup Med (Lond)* 2015;65:615-625.
- 29  
30  
31 17. Stocks SJ, McNamee R, van der Molen H, et al. Trends in incidence of occupational asthma, contact dermatitis, noise-induced hearing loss, carpal tunnel syndrome and upper limb musculoskeletal disorders in European countries from 2000 to 2012. *Occup Environ Med* 2015;72:294-303.
- 32  
33  
34  
35 18. Leinonen T, Viikari-Juntura E, Husgafvel-Pursiainen K. Labour market segregation and gender differences in sickness absence: trends in 2005-2013 in Finland. *Annals of Work Exposures and Health* 2017, 1-12.
- 36  
37  
38  
39 19. Sauni R, Kivekäs J, Uitti J. Uudet työkyvyttömyyseläkkeet ovat vähentyneet neljänneksen. *Suom Laakaril* 2015;70:3056-3057. [Finnish, no English Summary]
- 40  
41  
42  
43 20. Statistics Finland. Occupational accidents statistics. <http://www.stat.fi/til/ttap/2013/index.html>; Appendix table 3 [Liitetaulukko 3. Palkansaajien työpaikkatapaturmat 1976-2013] ([accessed 1 Feb 2018](#))
- 44  
45  
46  
47 21. Roto P, Sainio H, Reunala T, et al. Addition of ferrous sulfate to cement and risk of chromium dermatitis among construction workers. *Contact Dermatitis* 1996;34(1):43-50.
- 48  
49  
50  
51 22. Turjanmaa K, Alenius H, Reunala T, et al. Recent developments in latex allergy. *Curr Opin Allergy Clin Immunol* 2002;2:407-12.
- 52  
53  
54 23. Turner S, McNamee R, Agius R, et al. Evaluating intervention aimed at reducing occupational exposure to latex and rubber glove allergens. *Occup Environ Med* 2012;69:925-931.
- 55  
56  
57  
58  
59  
60

1  
2  
3 24. Stocks SJ, McNamee R, Turner S, et al. Assessing the impact of national level interventions on  
4 workplace respiratory disease in the UK: part 1 – changes in workplace exposure legislation and  
5 market forces. *Occup Environ Med* 2013;70:476-482.

6  
7 25. Stocks SJ, McNamee R, Turner S, et al. Assessing the impact of national level interventions on  
8 workplace respiratory disease on the UK: part 2 –regulatory activity by the Health and Safety  
9 Executive. *Occup Environ Med* 2013;70:483-490.

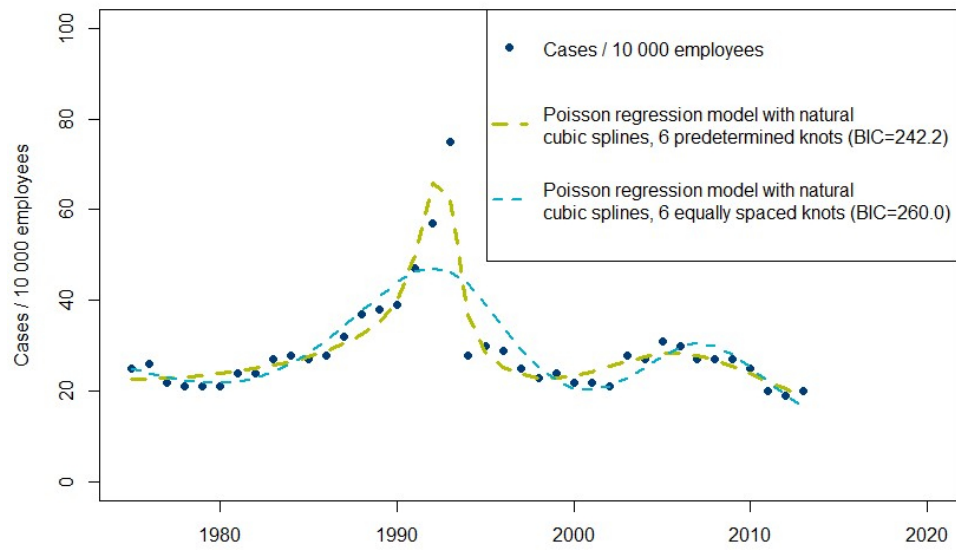
10  
11  
12  
13  
14 Figure 1. Fitting the cases of occupational diseases and suspected cases of occupational diseases/  
15 10,000 employees for 1975–2013 in the Poisson regression model.

16  
17  
18 Fig. 2 Recognized and suspected occupational diseases in Finland. The five-year moving average  
19 from 1975 to 2013. The arrows indicate important events influencing incidence rates.

20  
21  
22 Fig 3. Rate ratios of recognized and suspected occupational diseases by field of industry in Finland in  
23 1975–2013. The reference group is financial and insurance activities (K), RR=1.00.

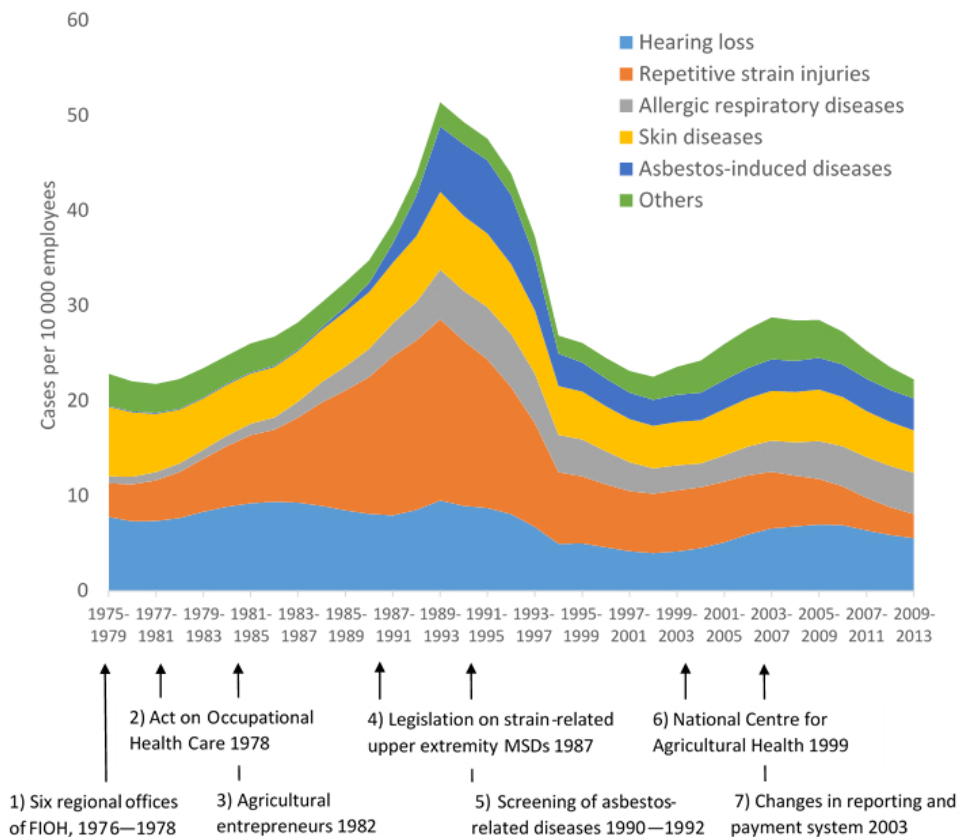


1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



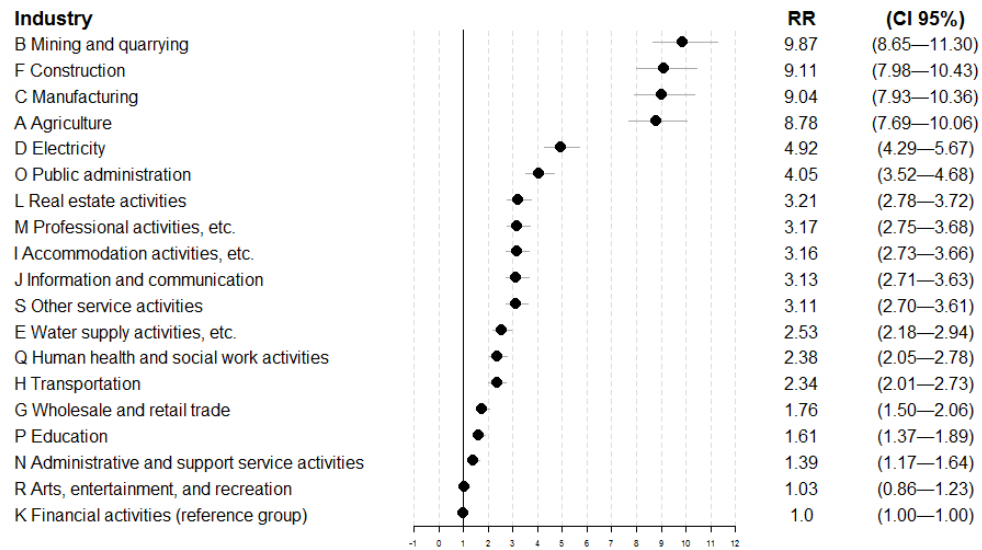
Fitting the cases of occupational diseases

224x156mm (96 x 96 DPI)



Recognized and suspected occupational diseases in Finland.

194x168mm (96 x 96 DPI)



Rate ratios of recognized and suspected occupational diseases

321x185mm (72 x 72 DPI)

Completed reporting checklist/ Trends in occupational diseases in Finland, 1975-2013 by Oksa P et al. /26 June 2018

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found PAGE 2
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported PAGE 4
Objectives	3	State specific objectives, including any prespecified hypotheses PAGE 5
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper PAGE 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection PAGES 5,6
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case PATIENTS WERE NOT INVOLVED
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable PAGES 5, 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group PAGES 5, 6
Bias	9	Describe any efforts to address potential sources of bias PAGE 5
Study size	10	Explain how the study size was arrived at ALL CASES WERE INCLUDED
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why PAGE 6
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding PAGE 6 (b) Describe any methods used to examine subgroups and interactions PAGE 6 (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

sampling strategy

---

(e) Describe any sensitivity analyses

Continued on next page

For peer review only

**Results**

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

**Discussion**

Key results	18	Summarise key results with reference to study objectives PAGE 9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias PAGE11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence PAGE11
Generalisability	21	Discuss the generalisability (external validity) of the study results PAGE 12

**Other information**

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based PAGE13
---------	----	--

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Trends in Occupational Diseases in Finland, 1975–2013

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-024040.R1
Article Type:	Research
Date Submitted by the Author:	09-Nov-2018
Complete List of Authors:	Oksa, Panu; Finnish Institute of Occupational Health Sauni, Riitta; Ministry of Social Affairs and Health, Department for Work and Gender Equality Talola, Nina; University of Tampere Virtanen, Simo; Finnish Institute of Occupational Health, Operations and Project Support Nevalainen, Jaakko; University of Tampere Saalo, Anja; Finnish Institute of Occupational Health Uitti, Jukka; University of Tampere, Faculty of Medicine and Life Sciences
<b>Primary Subject Heading</b>:	Occupational and environmental medicine
Secondary Subject Heading:	Occupational and environmental medicine
Keywords:	OCCUPATIONAL & INDUSTRIAL MEDICINE, Statistical trend, Occupational diseases register, Register study

SCHOLARONE™  
Manuscripts

Manuscript 191018

## Trends in Occupational Diseases in Finland, 1975–2013

### - a register study

Panu Oksa, MD, PhD

Finnish Institute of Occupational Health, Tampere, Finland

[panu.oksa@ttl.fi](mailto:panu.oksa@ttl.fi)

Riitta Sauni, MD, PhD

Department for Work and Gender Equality Ministry of Social Affairs and Health, Tampere, Finland

[riitta.sauni@stm.fi](mailto:riitta.sauni@stm.fi)

Nina Talola, MSc

Faculty of Medicine and Life Sciences, University of Tampere, Tampere, Finland

[Nina.Talola@uta.fi](mailto:Nina.Talola@uta.fi)

Simo Virtanen, PhD

Operations and Project Support, Finnish Institute of Occupational Health, Helsinki, Finland

[simo.virtanen@ttl.fi](mailto:simo.virtanen@ttl.fi)

Jaakko Nevalainen, PhD, Professor

Health Sciences, Faculty of Social Sciences, University of Tampere, Tampere, Finland

[Jaakko.Nevalainen@uta.fi](mailto:Jaakko.Nevalainen@uta.fi)

Anja Saalo, MSc

Finnish Institute of Occupational Health, Helsinki, Finland

[anja.saalo@gmail.com](mailto:anja.saalo@gmail.com)

Jukka Uitti, MD, Professor



1  
2  
3 Faculty of Medicine and Life Sciences, University of Tampere, Tampere, Finland

4 [jukka.uitti@uta.fi](mailto:jukka.uitti@uta.fi)

5  
6  
7  
8 Corresponding author:

9 Nina Talola, MSc

10 University of Tampere

11 Faculty of Medicine and Life Sciences

12 PB 100

13 FI -33014 UNIVERSITY OF TAMPERE

14 FINLAND

15 Email: nitalola@kotikone.fi

16  
17  
18  
19  
20  
21  
22  
23  
24  
25 Word count, excluding title page, abstract, acknowledgments, references, figures, and tables: 3,025

## 26 27 28 29 ABSTRACT

30 Objectives. The objective was to investigate trends in the incidence of recognized and suspected  
31 cases of occupational diseases in Finland from 1975 to 2013, including variations by industry – and  
32 describe and recognize factors affecting variations in incidence.

33  
34 Design. A register study.

35  
36 Setting. The data consisted of recognized and suspected cases of occupational diseases recorded in  
37 the Finnish Registry of Occupational Diseases (FROD) in 1975–2013.

38  
39 Participants. Altogether 240 000 cases of suspected and recognized ODs were analysed. Primary and  
40 secondary outcome measures From the annual workforce statistics and FROD data, we calculated  
41 the incidence of occupational diseases and suspected occupational diseases per 10,000 employees.  
42 For time trends by industrial sector, we used a five-year moving average and a Poisson regression  
43 analysis.

44  
45 Results. Annual average rates of occupational diseases have varied from year to year. The total  
46 number was 25.0/10,000 employees in 1975 and 20.1/10,000 employees in 2013. Screening  
47 campaigns and legislative changes have caused temporary increases. When the financial sector was  
48 the reference (1.0), the highest incidence rates according to industrial sector were in mining and  
49 quarrying (9.87; 95% CI 8.65–11.30), construction (9.11; 95% CI 9.98–10.43), manufacturing (9.04;  
50 95% CI 7.93–10.36), and agriculture (8.78; 95% CI 7.69–10.06). There is a distinct decreasing trend  
51 from 2005 onwards: the average annual change in incidence was, for example, -9.2% in agriculture, -  
52 10.3% in transportation, and -4.7% in construction. The average annual decline was greatest in  
53 upper limb strain injuries (-11.1%).

54  
55 Conclusion. This study provides a useful overview of the status of occupational diseases in Finland  
56 over several decades. These data are a valuable resource for determining which occupations are at

1  
2  
3 an increased risk and where preventive actions should be targeted. It is important to study long-  
4 term trends in the statistics of occupational diseases to see beyond the year-to-year fluctuations.  
5  
6  
7

### 8 **Strength and limitation of this study**

9

- 10 • National statistics on occupational diseases and short follow-ups have been published;  
11 however, year-to-year fluctuations make it difficult to discover the real long-term trends. A  
12 follow-up of almost 40 years provides a useful overview of the status of occupational  
13 diseases (ODs).  
14
- 15 • The Finnish surveillance system has been considered as comprehensive. Because the register  
16 is based on compensation system, the under-reporting is not a major problem.  
17
- 18 • Every physician is obligated to notify diagnosed and suspected cases of ODs, but not all  
19 physicians have training in occupational medicine, and may thus fail to connect diseases  
20 with working conditions.
- 21 • This overview is a valuable resource for determining which occupations are at an increased  
22 risk and where preventive actions should be targeted.
- 23 • A limitation of this study is that based on the data on the incidence of the ODs we can only  
24 give suggestions for the factors behind the changes of trends.  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## INTRODUCTION

According to the World Health Organization, an occupational disease is any disease contracted primarily as the result of an exposure to risk factors arising from work activity. Work-related diseases (WRDs) have multiple causes, and factors in the work environment may play a role – together with other risk factors – in the development or worsening of such diseases. Occupational diseases (ODs) are an important part of WRDs. All WRDs indicate defects in working conditions or the working environment, but only ODs are reported, and their exact numbers are recorded in registries. The number of ODs can be considered an indicator of efficient preventive actions in the workplace.

The European Union's occupational safety and health strategy for 2014–2020 emphasizes the prevention of occupational and other work-related diseases [1]. The Ministry of Social Affairs and Health in Finland has set a goal to reduce the number of ODs [2]. The reliable statistical data collection of ODs is important to enable evidence-based policy-making. It is equally important to know the factors behind the numbers of ODs. Changes in the incidence of ODs reflect changes in the conditions and processes of workplaces, but also a greater awareness of health risks among workers, employers, and physicians; improved investments by occupational health and safety (OSH) organizations; better education and national preventive campaigns; and changes in legislation. We need to have up-to-date data of ODs, and we must analyse the effects of working conditions, legislation, and, for example, screening campaigns on ODs. Of course, given the wide range of influential factors, it is very difficult to differentiate the effect of each simultaneous factor on OD incidence.

An OD that entitles the sufferer to compensation in accordance with Finnish legislation is a disease caused by any physical factor, chemical substance, or biological agent encountered in the course of work carried out under a contract of employment, in public service or office, or as an agricultural entrepreneur, as prescribed in the Occupational Accidents, Injuries and Diseases Act (459/2015) and the Governmental Decree on the Ordinance on Occupational Diseases (769/2016). The decree contains a list of physical, chemical, and biological factors and the diseases that may be caused by these factors, which are mostly based on epidemiological or clinical evidence. This list is updated from time to time; for example, carpal tunnel syndrome (2003) and retroperitoneal fibrosis caused by asbestos (2015) were added to the list. The list is not exhaustive, however: factors or diseases not on the list can also be suspected and recognized as causing or being an occupational disease if a causal relationship between the exposure and the disease can be proved in an individual case, as in many respiratory and skin allergies determined by provocation or skin tests, for example. The Finnish Register of Occupational Diseases (FROD) enables the follow-up of trends in the incidence of occupational diseases from 1964 onwards.

1  
2  
3 The aim of this study was to investigate trends in the incidence of recognized and suspected cases of  
4 ODs in Finland from 1975 to 2013 – including variations by industry – and to describe and recognize  
5 factors affecting variations in incidence.  
6  
7  
8  
9

## 10 MATERIAL AND METHODS

11  
12 The FROD kept by the Finnish Institute of Occupational Health (FIOH) was established in 1964, and it  
13 was consolidated as a research register by Finnish legislation in 1993. The objectives of the FROD are  
14 to serve as a source of statistics on occupational diseases, and to promote research and preventive  
15 measures in occupational health. Insurance companies send information on occupational diseases  
16 suspected or diagnosed by Finnish physicians to the Finnish Workers' Compensation Center (TVK).  
17 The FROD is compiled from information from the TVK and the Farmers' Social Insurance Institution  
18 (Mela). According to the Act on the Supervision of Labour Protection (44/2006), physicians are  
19 obligated to report cases of ODs and work-related illnesses to the Regional State Administrative  
20 Agencies, which then send forward reports to the FIOH. Information from this source can be used to  
21 augment and improve data in the FROD.  
22  
23  
24  
25  
26  
27  
28  
29

30 The Register's unit of observation is a filed claim of an occupational disease, either recognized or  
31 suspected. Since 2005, the FROD has gathered cases recognized by insurance companies and those  
32 that remain as suspicions of ODs separately. Recognition means that the insurance company has  
33 received sufficient data and decided to officially recognize a person's condition as an occupational  
34 disease in accordance with Finnish legislation. A recorded case (of an OD or its suspicion) contains  
35 detailed information on the timing, the patient's identification data (personal identity number, sex,  
36 age, occupation), information on the employer (field of industry, location of workplace), diagnosis,  
37 and the causes (exposures) and severity of the disease. The FROD is described in more detail in the  
38 report 'Occupational diseases in Finland in 2012' [3].  
39  
40  
41  
42  
43  
44  
45

46 The data for this study consisted of 240,000 recognized and suspected cases of ODs registered in the  
47 FROD between 1975 and 2013. The early years of the FROD (1964–1974) were excluded, as the  
48 number of cases on record was small. For our study, we extracted from the registry all cases and  
49 suspected cases of ODs and their registration year. We obtained the workforce data by field of  
50 industry from sources published by Statistics Finland [4]. Over the years, the field of industry  
51 categories have undergone several changes. The results of the study are presented according to the  
52 latest classification system from 2008 (TOL 2008), which is identical with NACE Rev.2 [5].  
53  
54  
55  
56  
57  
58  
59  
60

## Statistical methods

The variables presented here are the disease category, industry, and year of registration of the occupational disease or its suspicion. Using annual workforce statistics and cases and suspected cases of occupational diseases, we calculated the incidence of occupational diseases and suspected occupational diseases per 10,000 employees. For identifying longer term time trends, we used a five-year moving average.

To model the incidence of occupational disease trends between 1975 and 2013, we used a Poisson regression model with natural cubic splines using the splines package with the ns function in R statistical software [6]. With the natural cubic spline, we were able to reach detect the peak in incidence that occurred in 1993. We evaluated tested two different models, one with equally spaced knots and one with six predetermined knots. We used the Bayesian information criterion (BIC) to choose the best fitting model, which was the one with six predetermined knots (see Figure 1). The rate ratios (RR) and the 95% confidence intervals (95% CIs) for the incidence of occupational diseases for each industry were calculated using a Poisson regression model with cubic splines.

## Patient and public involvement

We analyzed register data and did not seek information from individuals. In other words, there was no patients or public involvement in the study.

## Classification of ODs

In the statistics, occupational diseases are classified into the following disease groups according to diagnosis and cause (for a detailed classification see Appendix 5 in ref [3]).

**Hearing loss** Noise-induced hearing loss refers to the deterioration of hearing due to prolonged exposure to noise or occasionally due to momentary impulse noise.

**Repetitive strain injury of upper limbs** A repetitive strain injury is a musculoskeletal disease caused by non-physiological stress at work (repetitive and monotonous work, unusual working postures).

1  
2  
3 The group includes tenosynovitis, peritendinitis, epicondylitis, bursitis, and mononeuropathy (e.g.  
4 carpal tunnel syndrome) of the upper limbs.  
5  
6

7 **Allergic respiratory diseases** Allergic respiratory diseases include asthma, allergic rhinitis, allergic  
8 alveolitis, and chronic laryngitis.  
9  
10

11 **Skin diseases** Occupational skin diseases are caused by chemical agents or micro-organisms in the  
12 work environment; the most significant diseases in this group are irritant contact dermatitis and  
13 allergic contact dermatitis.  
14  
15

16 **Asbestos-induced diseases** The group includes all occupational diseases caused by asbestos –  
17 pleural plaques, adhesions and calcifications being the most frequent. Lung cancer and asbestosis  
18 are the most severe diseases in this group.  
19  
20  
21

22 **Others** The group includes, for example, infectious diseases, conjunctivitis, hand-arm vibration  
23 syndrome, and various types of poisoning, including solvent-induced encephalopathy.  
24  
25  
26  
27  
28  
29

## 30 RESULTS

31  
32  
33

34 Altogether, 240,000 cases of suspected and recognized ODs were analysed. Annual average rates  
35 varied from year to year. The total number was 25.0/10,000 employees in 1975 and 20.1/10,000  
36 employees in 2013. From 1975 to 2013, the Finnish workforce increased from 2.1 million to 2.6  
37 million. Figure 2 presents the time trends of different disease groups from 1975 to 2014. The arrows  
38 indicate important incidents/events that have had an influence on incidence rates.  
39  
40  
41  
42  
43  
44

45 Figure 3 presents the rate ratios of ODs in different fields of industry for 1975–2013. The highest rate  
46 ratio was in mining and quarrying (9.87; 95%CI 8.65–11.30) and construction (9.11; 95%CI 7.98–  
47 10.43), when the reference group was financial and insurance activities (RR=1.00).  
48  
49  
50  
51  
52

53 There is a distinct decreasing trend in ODs from 2005 onwards: the average annual change in  
54 incidence was, for example, -9.2% in agriculture, -10.3% in transportation, and -4.7% in construction  
55 (see Table 1).  
56  
57  
58  
59  
60

The annual incidence rate of all notified cases declined from 31/10,000 employees in 2005 to 20/10,000 employees in 2013. The reduction in the incidence rate of recognized occupational diseases is more distinct than that of suspected cases: the annual incidence of recognized cases declined from 16/10,000 employees to 8/10,000 employees, while the annual incidence of suspected cases dropped from 16/10,000 employees to 12/10,000 employees. The average annual decline was greatest in upper limb strain injuries (-11.1%; see Table 2).

Table 1. Annual number and average incidence rate (95 % CI) per 10,000 employees, and average percentage change and 95% confidence interval in incidence of occupational disease in Finland for 2015–2013 by field of industry.

Field of industry	Recognized ODs (2005–2013)		Suspected ODs (2005–2013)	
	Annual average incidence rate (95% CI) per 10,000 employees	Annual average percentage change in incidence (95% CIs)	Annual average incidence rate (95% CI) per 10,000 employees	Annual average percentage change in incidence (95% CIs)
A Agriculture	39.5 (30.8, 48.1)	- 9.2 (-10.2, -8.2)	31.2 (24.5, 37.9)	- 9.8 (-11.0, -8.6)
B Mining	35.4 (29.8, 41.0)	- 4.8 (-8.1, -1.5)	22.2 (18.3, 26.0)	- 10.2 (-4.2, -16.1)
C Manufacturing	26.0 (22.6, 29.3)	- 4.5 (-4.9, -4.1)	24.6 (23.2, 26.0)	- 0.7 (-0.9, -0.5)
F Construction	29.9 (26.4, 33.3)	- 4.7 (-5.4, -4.0)	19.8 (17.6, 22.0)	- 0.3 (-0.5, -0.09)
Others	7.0 (6.0, 7.9)	- 5.7 (-6.2, -5.2)	9.6 (8.9, 10.3.9)	- 2.6 (-3.2, -2.0)
<b>Total</b>	11.7 (9.8, 13.6)	- 6.7 (-7.0, -6.4)	13.5 (12.5, 14.6)	- 2.8 (-3.0, -2.6)

Table 2. Annual number and average incidence rate (95 % CI) per 10,000 employees, and percentage change and 95% confidence interval of recognized and suspected occupational diseases in Finland for 2005–2013.

Occupational disease	Recognized ODs (2005–2013)			Suspected ODs (2005–2013)		
	Number of cases	Annual average incidence rate (95% CI) per 10,000 employees	Annual average percentage change in incidence (95% CIs)	Number of cases	Annual average incidence rate (95% CI) per 10,000 employees	Annual average percentage change in incidence (95% CIs)
Hearing loss	8,299	4.0 (3.2, 4.8)	- 8.1 (-8.7, -7.5)	4,542	2.2 (2.0, 2.4)	1.2 (0.9, 1.5)
Repetitive strain injuries	3,093	1.5 (1.1, 1.9)	- 11.1 (-12.2, -10.0)	4,648	2.2 (1.6, 2.9)	- 13.2 (-14.2, -12.2)
Allergic respiratory diseases	1,896	0.9 (0.7, 1.1)	- 7.8 (-9.0, -6.6)	6,556	3.1 (2.8, 3.5)	2.8 (2.4, 3.2)

1							
2							
3							
4	Skin diseases	4,295	2.1 (1.7, 2.4)	- 6.5 (-7.2, -5.8)	5,988	2.9 (2.7, 3.0)	-0.1 (-0.2, -0.02)
5	Asbestos-induced						
6	diseases	5,330	2.5 (2.4, 2.7)	- 1.7 (-2.0, -1.4)	1,640	0.8 (0.7, 0.9)	0.0 (0, 0)
7							
8	Others	1,530	0.7 (0.5, 0.9)	- 11.1 (-12.7, -9.5)	4,752	2.3 (1.6, 2.9)	- 7.9 (-8.7, -7.1)
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							
51							
52							
53							
54							
55							
56							
57							
58							
59							
60							

## DISCUSSION

Our results indicate that there has been a remarkable year-to-year fluctuation in the incidence of occupational diseases due to various causes; the analysis of long-term trends is needed to understand the overall direction of the changes. In-depth analysis of the trends in different branches reveals the areas where more preventive efforts are needed.

### 1970s

The increase in the incidence of ODs in the 1970s coincided with the establishment of the six regional offices of the FIOH. The purpose of the regional offices was to support local workplaces and to educate OSH personnel. This became possible as the FIOH was granted judicial status in the 1970s and it started to receive annual funding from the state. The first act on FIOH action was passed in 1978 (159/1978).

Furthermore, the former voluntary occupational health care system became mandatory in Finland in 1978 (Act 743/1978). The increasing number of professionals in occupational health care is supposedly related to the increasing number of notifications of ODs, and thus the increasing incidence of ODs in the register. Gradually, over three years, all private and public organizations with at least one employee had to arrange occupational health services for their workers. Mandatory services included, for example, workplace surveys and medical health examinations for workers. The number of workers covered by occupational health services increased remarkably, from approximately 1.1 million in 1978 (60% of all employees), to 1.6 million (80%) in 1983, to 1.9 million (87%) in 2013 [7]. In addition, the number of health examinations increased, revealing more ODs, which consequently resulted in the increase in the incidence of ODs.

### 1980s



1  
2  
3 Since 1978, farmers' pension insurance has included mandatory accident insurance (MATA), which  
4 provides compensation for occupational diseases caused by agricultural work. Guidelines for  
5 farmers' occupational health care were provided to municipal health centres in 1984, and farm visits  
6 were fully compensated by the state (Act 859/1984). Several campaigns were launched to encourage  
7 farmers to utilize occupational health care services.  
8  
9

10  
11  
12 The Governmental Decree on the Ordinance on Occupational Diseases contains a list of physical,  
13 chemical, and biological factors and the diseases caused by these factors. Updates to this list have  
14 resulted in the recognition of new ODs. A substantial increase in strain-related upper extremity  
15 musculoskeletal disorders was brought about by the changes in Decree 67/1987. With this decree,  
16 epicondylitis and tendinitis of the forearm became compensatory if the condition resulted from  
17 repetitive and one-sided movement or movement that was unfamiliar to the worker.  
18  
19  
20  
21  
22

### 23 **1990s**

24  
25 Screening for asbestos-induced diseases in Finland was carried out from 1990 to 1992 as part of the  
26 FIOH's Asbestos Program. Altogether, 18,900 employees were examined, and 3,500 new  
27 asbestos-related ODs were diagnosed. Most of them were benign pleural changes/plaques, but  
28 there were also 800 cases of asbestosis. The number of asbestos related diseases reported to the  
29 register multiplied for years after the campaign [8].  
30  
31  
32  
33

34 The founding of a National Centre for Agricultural Health (NCAH) in 1999 was a further push to  
35 develop working conditions in farming and to encourage more farmers to utilize occupational health  
36 care.  
37  
38  
39

### 40 **2000s**

41  
42 From 2003, insurance institutions have sent data on new ODs and suspected ODs to the Workers'  
43 Compensation Center (TVK). The FROD obtains its information from the TVK and the Farmers' Social  
44 Insurance Institution, Mela. Before 2003, insurance institutions sent data directly to the FROD.  
45 Information from Regional State Administrative Agencies (given by physicians) can be used to  
46 complete the data on diseases in the FROD.  
47  
48  
49  
50

51 In Finland, insurance companies pay for the examinations of both suspected and recognized ODs.  
52 The insurance institutions' payment system changed in 2003, however; medical units could claim  
53 examination costs directly from insurance institutions. Prior to 2003, insurance companies paid  
54 yearly a sum of money to the state as compensation for the medical examinations of ODs conducted  
55 at municipal medical centres and hospitals.  
56  
57  
58  
59  
60

1  
2  
3 In Finland, manufacturing, mining and quarrying, construction, agriculture, forestry, and fishing have  
4 clearly had the highest incidence rates of ODs over the decades, although there has been a  
5 decreasing trend since 2005. They are all branches involving manual, physically demanding work,  
6 and several possible occupational exposures are common. Construction work is a good example,  
7 because it includes various health hazards, such as exposure to physical stress, dust, noise, and  
8 vibration. Construction workers have been shown to be at an increased risk of work-related ill health  
9 and injury both in Europe and globally [9]. They have an increased risk of cancer, respiratory  
10 diseases, musculoskeletal disorders, and injuries compared to the general population [10]. The  
11 incidence of skin neoplasia, contact dermatitis, musculoskeletal disorders, mesothelioma, lung  
12 cancer, pneumoconiosis, and other benign pleural diseases is also increased among construction  
13 workers compared to the rest of the working population [11]. The trends of ODs in the construction  
14 sector are not decreasing everywhere: significantly increasing trends in noise-induced hearing loss  
15 and work-related contact dermatitis were observed in the construction sector in the Netherlands in  
16 2010–2014 [12]. An examination of trends and patterns in occupational illnesses among construction  
17 workers from 1992 to 2014 in the USA showed that construction workers continue to face a higher  
18 risk of work-related musculoskeletal disorders [13].

19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31 The Finnish surveillance system has been considered comprehensive. In an evaluation of  
32 occupational disease surveillance in six EU countries the Finnish Register of Occupational Diseases  
33 was rated as one of the best ones [14]. Every physician is obligated to report diagnosed and  
34 suspected cases of ODs. FROD offers data on the incidence of ODs from 1964 onwards. Because the  
35 register is based on a compensation system, under-reporting is not a major problem. Nevertheless,  
36 some physicians may neglect to report occupational diseases. Moreover, not all physicians are  
37 trained in occupational medicine, and some may thus fail to connect diseases with working  
38 conditions. For these reasons, some occupational diseases may remain either undiagnosed or  
39 unrecorded. The period of interest was almost 40 years, so it impossible to take into account all  
40 variables which have affected incidences of ODs. Some factors may be missing although we  
41 systematically have gone through all potential influential ones.

42  
43  
44  
45  
46  
47  
48  
49  
50 Registries and occupational diseases differ considerably in various countries in terms of the criteria  
51 for registration and notification, statistical data provided, and legal context [14, 15]. Therefore,  
52 figures on ODs are not necessarily comparable between countries. The ability to compare would be  
53 beneficial for improving occupational health policies and facilitating coordinated research. A  
54 comparison of OD surveillance systems in the EU countries has been recently published in order to  
55 facilitate this work in the future [16].

1  
2  
3 The direct comparison of trends in OD within Europe showed that reports of contact dermatitis and  
4 asthma were declining in most countries, which is consistent with the positive impact of European  
5 initiatives addressing the relevant exposures [17]. This finding is consistent with the results of the  
6 present study, although the largest decline we noted was in the numbers of upper limb  
7 musculoskeletal disorders.  
8  
9

10  
11  
12 The main reasons for the fluctuation of OD incidence rates in Finland include changes in legislation –  
13 such as the addition of new diseases to the list of occupational diseases – screening campaigns, and  
14 developments in technology and occupational safety and health.  
15  
16

17  
18 The decline in the incidence of ODs in 2005–2013 has occurred at the same time as changes in fields  
19 of industry have continued. The number of workplaces in manufacturing has declined as the number  
20 of service workplaces has grown. Some 48.3% of men were employed in manual work in 2005; by  
21 2013, the percentage had dropped to 45.5%. For women, the numbers were 22% and 17.5%,  
22 respectively [18]. These changes influence the annual number and incidence rate of ODs (Table 2),  
23 but the reduction is also true in most other fields of industry (Table 1). Both the number of people  
24 leaving the workforce on disability pensions and the frequency of occupational accidents have  
25 decreased. The largest reduction was seen in 2006–2014, when the annual number of new disability  
26 pensions diminished by 26% [19]. The total number of occupational accidents declined by 27% in  
27 2006–2013 [20]. We assume that these three phenomena can be connected to the improvement of  
28 working conditions and activities of occupational health services.  
29  
30  
31  
32  
33  
34  
35

36  
37 There is evidence that technical improvements and innovations in processes may decrease the  
38 number of ODs. For example, passivating chromate by adding iron (II) sulphate to cement markedly  
39 reduced the allergic contact dermatitis incidence among construction workers [21]. In addition, the  
40 end of the practice of using latex gloves resulted in a reduction in allergic contact dermatitis in  
41 health care workers [22, 23]. In the UK, a significant reduction in the incidence of short latency  
42 respiratory disease and asthma attributed to glutaraldehyde or latex coincided with changes in  
43 legislation, mandatory advice from the Medical Devices Agency, new exposure limits, and the  
44 removal of glutaraldehyde-based disinfectants from the market [24, 25].  
45  
46  
47  
48  
49

50  
51 This study provides a useful overview of the status of occupational diseases in Finland over several  
52 decades. These data are a valuable resource for determining which occupations are at an increased  
53 risk and where preventive actions should be targeted. It is important to study the long-term trends  
54 in the statistics of occupational diseases to see the bigger picture beyond the year-to-year  
55 fluctuations.  
56  
57  
58  
59  
60

## ACKNOWLEDGEMENTS

We wish to thank the many experts at the FIOH for their fruitful comments on this study. In particular, we wish to express our gratitude to our colleagues at the FROD, especially Lea Palo (long-term Research Secretary) and Ilpo Mäkinen for their proficiency in maintaining the high quality and reliability of the Registry.

Figure 1. Fitting the cases of occupational diseases and suspected cases of occupational diseases/10,000 employees for 1975–2013 in the Poisson regression model.

Fig. 2 Recognized and suspected occupational diseases in Finland. The five-year moving average from 1975 to 2013. The arrows indicate important events influencing incidence rates.

Fig 3. Rate ratios of recognized and suspected occupational diseases by field of industry in Finland in 1975–2013. The reference group is financial and insurance activities (K), RR=1.00.

### Statements

#### a. Contributorship statement

PO: Primary investigator involved in the study design, study conduct and reporting. RS and JU: Co-primary investigators involved in the study design, data collecting and reporting. NT and JN: Co-investigators involved in statistical planning, data processing and reporting. SV and AS: Co-investigators involved in planning, data collecting, data processing and reporting.

#### b. Competing interests

None declared.

#### c. Funding

The Finnish Work Environment Fund funded the study (Project number 115142).

#### d. Data sharing statement

Information of published data from Finnish Registry of Occupational Diseases is available on website of Finnish Institute of Occupational Health. No unpublished data are available.

#### e. Ethical approval statement

Ethical approval was not required for this type of study (register study, anonymous data).

## REFERENCES

1. European Commission. Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions on an EU Strategic Framework on Health and Safety at Work 2014-2020. Brussels, 6.6.2014 COM(2014) 332 final.
2. Policies for the work environment and well-being at work until 2020. Publications of the Ministry of Social Affairs and Health : 2011:14
3. Oksa P, Palo L, Saalo A et al. Occupational diseases in Finland in 2012. New cases of recognized and suspected occupational diseases. FIOH Helsinki 2014, 79p. [http://urn.fi/URN:ISBN 978-952-261-470-4](http://urn.fi/URN:ISBN%20978-952-261-470-4) (pdf)
4. Statistics Finland, Population 2005:4. [Suomen Virallinen Tilasto, Väestö 2005:4; Tilastokeskuksen PX-Web -tietojärjestelmästä, Työssäkäynti, ”010 – Väestö alueen pääasiallisen toiminnan, sukupuolen, iän ja vuoden mukaan”] [http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin\\_vrm\\_tyokay/010\\_tyokay\\_tau\\_101.px/?rxid=e20431bb-9577-4ef1-9a1d-479c299dffe6](http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin_vrm_tyokay/010_tyokay_tau_101.px/?rxid=e20431bb-9577-4ef1-9a1d-479c299dffe6) (accessed 1 Feb 2018)
5. NACE Rev.2 <http://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF> (accessed 1 Feb 2018)
6. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>
7. Annual statistics. The Social Insurance Institution of Finland, Kela Statistics
8. Koskinen K, Rinne JP, Zitting A, et al. Screening for asbestos-induced diseases in Finland. *Am J Ind Med* 1996;30:241-51.
9. Watterson A. Global construction health and safety- what works, what does not, and why? *J Occup Environ Health* 2007;13:1-4.
10. Arndt V, Rothenbacher D, Daniel U, et al. Construction work and risk of occupational disability: a ten year follow up of 14 474 male workers. *Occup Environ Med* 2005;62:559–566.
11. Stocks SJ, McNamee R, Carder M, et al. The incidence of medically reported work-related ill-health in the UK construction industry. *Occup Environ Med* 2010;67:575-576.
12. van der Molen HF, de Vries SC, Stocks SJ, et al. Incidence rates of occupational diseases in the Dutch construction sector, 2010-2014. *Occup Environ Med* 2016;73:350-352
13. Wang X, Dong XS, Choi SD, et al. Work-related musculoskeletal disorders among construction workers in the United States from 1992 to 2014. *Occup Environ Med* 2017;74:374-380.
14. Spreeuwers D, de Boer AGEM, Verbeek JHAM, et al. Evaluation of occupational disease surveillance in six EU countries. *Occup Med (Lond)* 2010;60:509–516.
15. European Commission. Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions. Safer and Healthier Work for All - Modernisation of the EU Occupational Safety and Health Legislation and Policy. COM(2017) 12 Final. Brussels; 2017
16. Carder M, Bensefa-Colas L, Mattioli S et al. A review of occupational disease surveillance systems in Modernet countries. *Occup Med (Lond)* 2015;65:615-625.

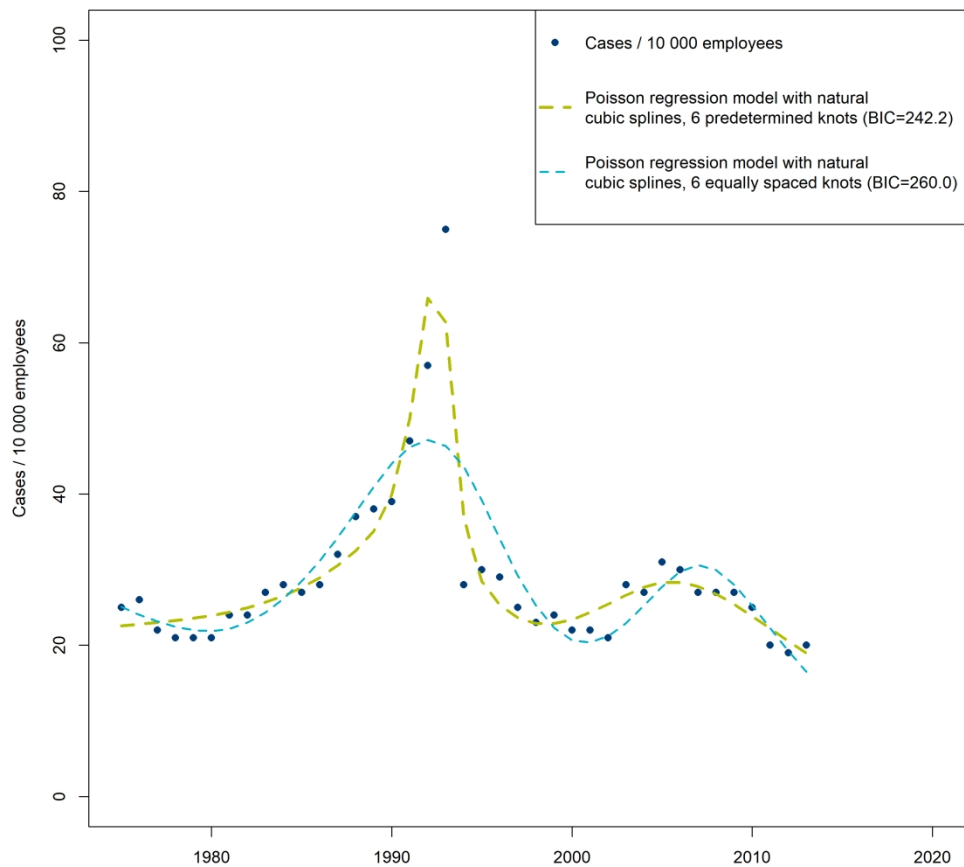
- 1  
2  
3 17. Stocks SJ, McNamee R, van der Molen H, et al. Trends in incidence of occupational asthma,  
4 contact dermatitis, noise-induced hearing loss, carpal tunnel syndrome and upper limb  
5 musculoskeletal disorders in European countries from 2000 to 2012. *Occup Environ Med*  
6 2015;72:294-303.  
7  
8 18. Leinonen T, Viikari-Juntura E, Husgafvel-Pursiainen K. Labour market segregation and gender  
9 differences in sickness absence: trends in 2005-2013 in Finland. *Annals of Work Exposures and*  
10 *Health* 2017, 1-12.  
11  
12 19. Sauni R, Kivekäs J, Uitti J. Uudet työkyvyttömyyseläkkeet ovat vähentyneet neljänneksen. *Suom*  
13 *Laakaril* 2015;70:3056-3057. [Finnish, no English Summary]  
14  
15 20. Statistics Finland. Occupational accidents statistics. <http://www.stat.fi/til/ttap/2013/index.html>;  
16 Appendix table 3 [Liitetaulukko 3. Palkansaajien työpaikkatapaturmat 1976–2013] ([accessed 1 Feb](#)  
17 [2018](#))  
18  
19 21. Roto P, Sainio H, Reunala T, et al. Addition of ferrous sulfate to cement and risk of chromium  
20 dermatitis among construction workers. *Contact Dermatitis* 1996;34(1):43-50.  
21  
22 22. Turjanmaa K, Alenius H, Reunala T, et al. Recent developments in latex allergy. *Curr Opin Allergy*  
23 *Clin Immunol* 2002;2:407-12.  
24  
25 23. Turner S, McNamee R, Agius R, et al. Evaluating intervention aimed at reducing occupational  
26 exposure to latex and rubber glove allergens. *Occup Environ Med* 2012;69:925-931.  
27  
28 24. Stocks SJ, McNamee R, Turner S, et al. Assessing the impact of national level interventions on  
29 workplace respiratory disease in the UK: part 1 – changes in workplace exposure legislation and  
30 market forces. *Occup Environ Med* 2013;70:476-482.  
31  
32 25. Stocks SJ, McNamee R, Turner S, et al. Assessing the impact of national level interventions on  
33 workplace respiratory disease on the UK: part 2 –regulatory activity by the Health and Safety  
34 Executive. *Occup Environ Med* 2013;70:483-490.  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

Figure 1. Fitting the cases of occupational diseases and suspected cases of occupational diseases/  
10,000 employees for 1975–2013 in the Poisson regression model.

Fig. 2 Recognized and suspected occupational diseases in Finland. The five-year moving average  
from 1975 to 2013. The arrows indicate important events influencing incidence rates.

Fig 3. Rate ratios of recognized and suspected occupational diseases by field of industry in Finland in  
1975–2013. The reference group is financial and insurance activities (K), RR=1.00.

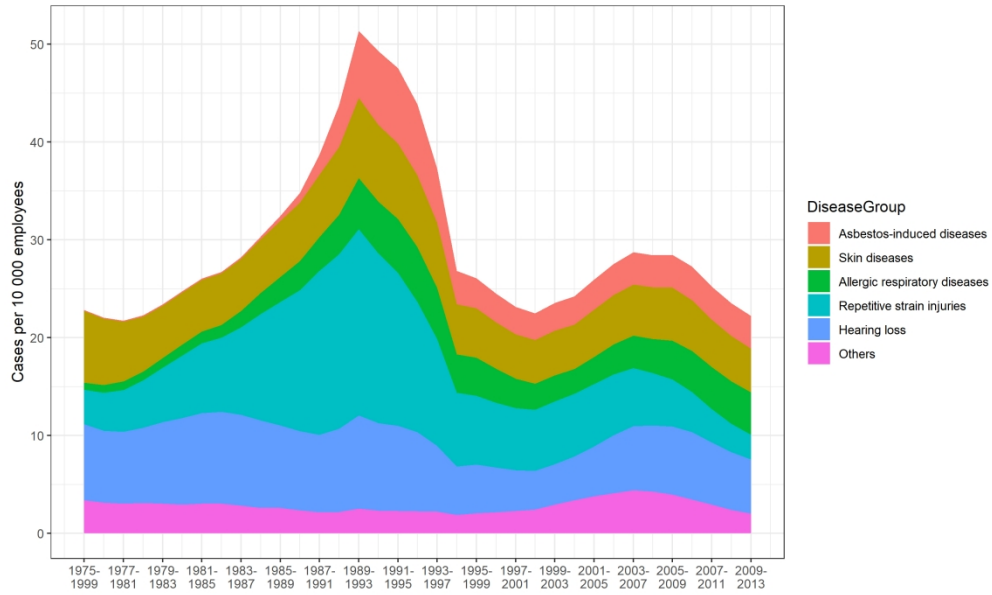
1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



Fitting the cases of occupational diseases

254x254mm (300 x 300 DPI)

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

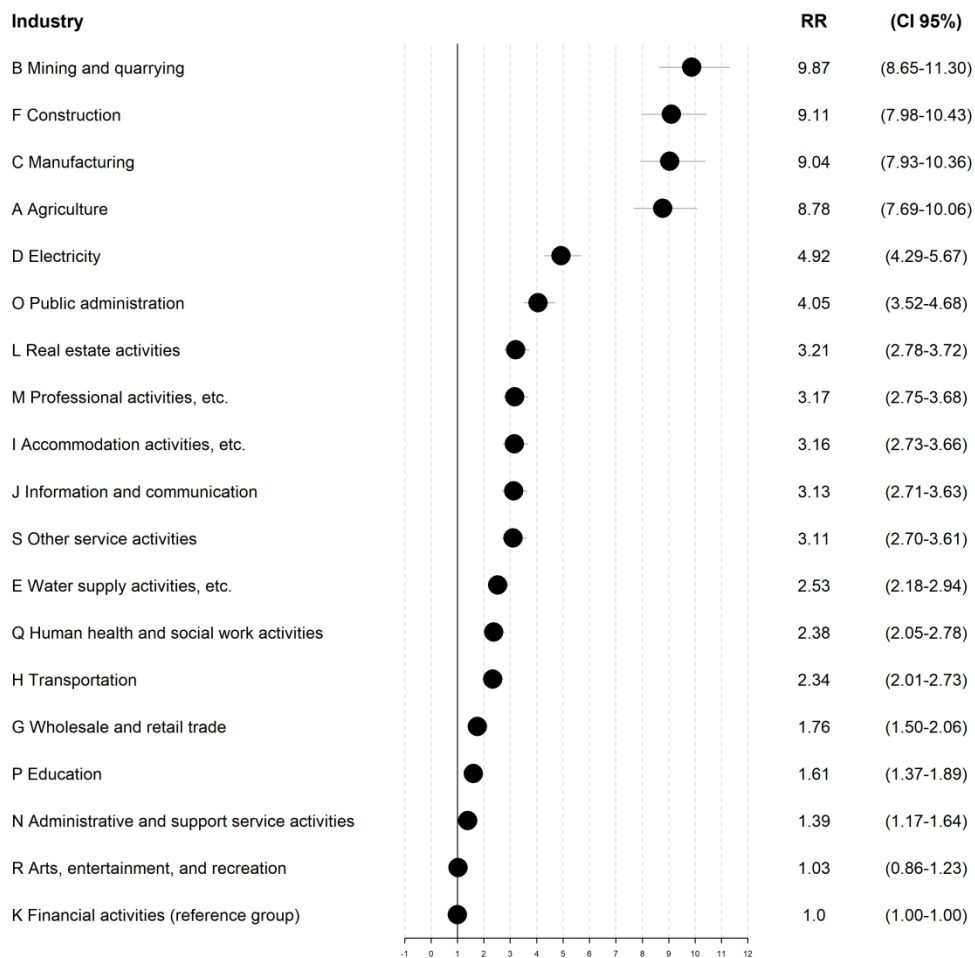


Recognized and suspected occupational diseases in Finland.

254x152mm (300 x 300 DPI)



1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



Rate ratios of recognized and suspected occupational diseases.

254x254mm (300 x 300 DPI)

Completed reporting checklist/ Trends in occupational diseases in Finland, 1975-2013 by Oksa P et al. /26 June 2018

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found PAGE 2
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported PAGE 4
Objectives	3	State specific objectives, including any prespecified hypotheses PAGE 5
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper PAGE 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection PAGES 5,6
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case PATIENTS WERE NOT INVOLVED
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable PAGES 5, 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group PAGES 5, 6
Bias	9	Describe any efforts to address potential sources of bias PAGE 5
Study size	10	Explain how the study size was arrived at ALL CASES WERE INCLUDED
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why PAGE 6
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding PAGE 6 (b) Describe any methods used to examine subgroups and interactions PAGE 6 (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of

1  
2 sampling strategy

---

3 (e) Describe any sensitivity analyses

4 Continued on next page

5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

For peer review only

**Results**

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

**Discussion**

Key results	18	Summarise key results with reference to study objectives PAGE 9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias PAGE11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence PAGE11
Generalisability	21	Discuss the generalisability (external validity) of the study results PAGE 12

**Other information**

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based PAGE13
---------	----	--

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Trends in Occupational Diseases in Finland, 1975–2013 - a register study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-024040.R2
Article Type:	Research
Date Submitted by the Author:	15-Jan-2019
Complete List of Authors:	Okša, Panu; Finnish Institute of Occupational Health Sauni, Riitta; Ministry of Social Affairs and Health, Department for Work and Gender Equality Talola, Nina; University of Tampere Virtanen, Simo; Finnish Institute of Occupational Health, Operations and Project Support Nevalainen, Jaakko; University of Tampere Saalo, Anja; Finnish Institute of Occupational Health Uitti, Jukka; University of Tampere, Faculty of Medicine and Life Sciences
<b>Primary Subject Heading</b>:	Occupational and environmental medicine
Secondary Subject Heading:	Occupational and environmental medicine
Keywords:	OCCUPATIONAL & INDUSTRIAL MEDICINE, Statistical trend, Occupational diseases register, Register study

SCHOLARONE™  
Manuscripts

Manuscript 191018

## Trends in Occupational Diseases in Finland, 1975–2013

### - a register study

Panu Oksa, MD, PhD

Finnish Institute of Occupational Health, Tampere, Finland

[panu.oksa@ttl.fi](mailto:panu.oksa@ttl.fi)

Riitta Sauni, MD, PhD

Department for Work and Gender Equality Ministry of Social Affairs and Health, Tampere, Finland

[riitta.sauni@stm.fi](mailto:riitta.sauni@stm.fi)

Nina Talola, MSc

Faculty of Medicine and Life Sciences, University of Tampere, Tampere, Finland

[Nina.Talola@uta.fi](mailto:Nina.Talola@uta.fi)

Simo Virtanen, PhD

Operations and Project Support, Finnish Institute of Occupational Health, Helsinki, Finland

[simo.virtanen@ttl.fi](mailto:simo.virtanen@ttl.fi)

Jaakko Nevalainen, PhD, Professor

Health Sciences, Faculty of Social Sciences, University of Tampere, Tampere, Finland

[Jaakko.Nevalainen@uta.fi](mailto:Jaakko.Nevalainen@uta.fi)

Anja Saalo, MSc

Finnish Institute of Occupational Health, Helsinki, Finland

[anja.saalo@gmail.com](mailto:anja.saalo@gmail.com)

Jukka Uitti, MD, Professor

1  
2  
3 Faculty of Medicine and Life Sciences, University of Tampere, Tampere, Finland

4 [jukka.uitti@uta.fi](mailto:jukka.uitti@uta.fi)

5  
6  
7  
8 Corresponding author:

9 Nina Talola, MSc

10 University of Tampere

11 Faculty of Medicine and Life Sciences

12 PB 100

13 FI -33014 UNIVERSITY OF TAMPERE

14 FINLAND

15 Email: nitalola@kotikone.fi

16  
17  
18  
19  
20  
21  
22  
23  
24  
25 Word count, excluding title page, abstract, acknowledgments, references, figures, and tables: 3,025

## 26 27 28 29 ABSTRACT

30 Objectives. The objective was to investigate trends in the incidence of recognized and suspected  
31 cases of occupational diseases in Finland from 1975 to 2013, including variations by industry – and  
32 describe and recognize factors affecting variations in incidence.

33  
34 Design. A register study.

35  
36 Setting. The data consisted of recognized and suspected cases of occupational diseases recorded in  
37 the Finnish Registry of Occupational Diseases (FROD) in 1975–2013.

38  
39 Participants. Altogether 240 000 cases of suspected and recognized ODs were analysed. Primary and  
40 secondary outcome measures From the annual workforce statistics and FROD data, we calculated  
41 the incidence of occupational diseases and suspected occupational diseases per 10,000 employees.  
42 For time trends by industrial sector, we used a five-year moving average and a Poisson regression  
43 analysis.

44  
45 Results. Annual average rates of occupational diseases have varied from year to year. The total  
46 number was 25.0/10,000 employees in 1975 and 20.1/10,000 employees in 2013. Screening  
47 campaigns and legislative changes have caused temporary increases. When the financial sector was  
48 the reference (1.0), the highest incidence rates according to industrial sector were in mining and  
49 quarrying (9.87; 95% CI 8.65–11.30), construction (9.11; 95% CI 9.98–10.43), manufacturing (9.04;  
50 95% CI 7.93–10.36), and agriculture (8.78; 95% CI 7.69–10.06). There is a distinct decreasing trend  
51 from 2005 onwards: the average annual change in incidence was, for example, -9.2% in agriculture, -  
52 10.3% in transportation, and -4.7% in construction. The average annual decline was greatest in  
53 upper limb strain injuries (-11.1%).

54  
55 Conclusion. This study provides a useful overview of the status of occupational diseases in Finland  
56 over several decades. These data are a valuable resource for determining which occupations are at

1  
2  
3 an increased risk and where preventive actions should be targeted. It is important to study long-  
4 term trends in the statistics of occupational diseases to see beyond the year-to-year fluctuations.  
5  
6  
7

### 8 **Strength and limitation of this study**

9

- 10 • National statistics on occupational diseases and short follow-ups have been published;  
11 however, year-to-year fluctuations make it difficult to discover the real long-term trends. A  
12 follow-up of almost 40 years provides a useful overview of the status of occupational  
13 diseases (ODs).  
14
- 15 • The Finnish surveillance system has been considered as comprehensive. Because the register  
16 is based on compensation system, the under-reporting is not a major problem.  
17
- 18 • Every physician is obligated to notify diagnosed and suspected cases of ODs, but not all  
19 physicians have training in occupational medicine, and may thus fail to connect diseases  
20 with working conditions.
- 21 • This overview is a valuable resource for determining which occupations are at an increased  
22 risk and where preventive actions should be targeted.
- 23 • A limitation of this study is that based on the data on the incidence of the ODs we can only  
24 give suggestions for the factors behind the changes of trends.  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



## INTRODUCTION

According to the World Health Organization, an occupational disease is any disease contracted primarily as the result of an exposure to risk factors arising from work activity. Work-related diseases (WRDs) have multiple causes, and factors in the work environment may play a role – together with other risk factors – in the development or worsening of such diseases. Occupational diseases (ODs) are an important part of WRDs. All WRDs indicate defects in working conditions or the working environment, but only ODs are reported, and their exact numbers are recorded in registries. The number of ODs can be considered an indicator of efficient preventive actions in the workplace.

The European Union's occupational safety and health strategy for 2014–2020 emphasizes the prevention of occupational and other work-related diseases [1]. The Ministry of Social Affairs and Health in Finland has set a goal to reduce the number of ODs [2]. The reliable statistical data collection of ODs is important to enable evidence-based policy-making. It is equally important to know the factors behind the numbers of ODs. Changes in the incidence of ODs reflect changes in the conditions and processes of workplaces, but also a greater awareness of health risks among workers, employers, and physicians; improved investments by occupational health and safety (OSH) organizations; better education and national preventive campaigns; and changes in legislation. We need to have up-to-date data of ODs, and we must analyse the effects of working conditions, legislation, and, for example, screening campaigns on ODs. Of course, given the wide range of influential factors, it is very difficult to differentiate the effect of each simultaneous factor on OD incidence.

An OD that entitles the sufferer to compensation in accordance with Finnish legislation is a disease caused by any physical factor, chemical substance, or biological agent encountered in the course of work carried out under a contract of employment, in public service or office, or as an agricultural entrepreneur, as prescribed in the Occupational Accidents, Injuries and Diseases Act (459/2015) and the Governmental Decree on the Ordinance on Occupational Diseases (769/2016). The decree contains a list of physical, chemical, and biological factors and the diseases that may be caused by these factors, which are mostly based on epidemiological or clinical evidence. This list is updated from time to time; for example, carpal tunnel syndrome (2003) and retroperitoneal fibrosis caused by asbestos (2015) were added to the list. The list is not exhaustive, however: factors or diseases not on the list can also be suspected and recognized as causing or being an occupational disease if a causal relationship between the exposure and the disease can be proved in an individual case, as in many respiratory and skin allergies determined by provocation or skin tests, for example. The Finnish Register of Occupational Diseases (FROD) enables the follow-up of trends in the incidence of occupational diseases from 1964 onwards.

1  
2  
3 The aim of this study was to investigate trends in the incidence of recognized and suspected cases of  
4 ODs in Finland from 1975 to 2013 – including variations by industry – and to describe and recognize  
5 factors affecting variations in incidence.  
6  
7  
8  
9

## 10 MATERIAL AND METHODS

11  
12 The FROD kept by the Finnish Institute of Occupational Health (FIOH) was established in 1964, and it  
13 was consolidated as a research register by Finnish legislation in 1993. The objectives of the FROD are  
14 to serve as a source of statistics on occupational diseases, and to promote research and preventive  
15 measures in occupational health. Insurance companies send information on occupational diseases  
16 suspected or diagnosed by Finnish physicians to the Finnish Workers' Compensation Center (TVK).  
17 The FROD is compiled from information from the TVK and the Farmers' Social Insurance Institution  
18 (Mela). According to the Act on the Supervision of Labour Protection (44/2006), physicians are  
19 obligated to report cases of ODs and work-related illnesses to the Regional State Administrative  
20 Agencies, which then send forward reports to the FIOH. Information from this source can be used to  
21 augment and improve data in the FROD.  
22  
23  
24  
25  
26  
27  
28  
29

30 The Register's unit of observation is a filed claim of an occupational disease, either recognized or  
31 suspected. Since 2005, the FROD has gathered cases recognized by insurance companies and those  
32 that remain as suspicions of ODs separately. Recognition means that the insurance company has  
33 received sufficient data and decided to officially recognize a person's condition as an occupational  
34 disease in accordance with Finnish legislation. A recorded case (of an OD or its suspicion) contains  
35 detailed information on the timing, the patient's identification data (personal identity number, sex,  
36 age, occupation), information on the employer (field of industry, location of workplace), diagnosis,  
37 and the causes (exposures) and severity of the disease. The FROD is described in more detail in the  
38 report 'Occupational diseases in Finland in 2012' [3].  
39  
40  
41  
42  
43  
44  
45

46 The data for this study consisted of 240,000 recognized and suspected cases of ODs registered in the  
47 FROD between 1975 and 2013. The early years of the FROD (1964–1974) were excluded, as the  
48 number of cases on record was small. For our study, we extracted from the registry all cases and  
49 suspected cases of ODs and their registration year. We obtained the workforce data by field of  
50 industry from sources published by Statistics Finland [4]. Over the years, the field of industry  
51 categories have undergone several changes. The results of the study are presented according to the  
52 latest classification system from 2008 (TOL 2008), which is identical with NACE Rev.2 [5].  
53  
54  
55  
56  
57  
58  
59  
60

## Statistical methods

The variables presented here are the disease category, industry, and year of registration of the occupational disease or its suspicion. Using annual workforce statistics and cases and suspected cases of occupational diseases, we calculated the incidence of occupational diseases and suspected occupational diseases per 10,000 employees. For identifying longer term time trends, we used a five-year moving average.

To model the incidence of occupational disease trends between 1975 and 2013, we used a Poisson regression model with natural cubic splines using the splines package with the ns function in R statistical software [6]. With the natural cubic spline, we were able to reach detect the peak in incidence that occurred in 1993. We evaluated tested two different models, one with equally spaced knots and one with six predetermined knots. We used the Bayesian information criterion (BIC) to choose the best fitting model, which was the one with six predetermined knots (see Figure 1). The rate ratios (RR) and the 95% confidence intervals (95% CIs) for the incidence of occupational diseases for each industry were calculated using a Poisson regression model with cubic splines.

## Patient and public involvement

We analyzed register data and did not seek information from individuals. In other words, there was no patients or public involvement in the study.

## Classification of ODs

In the statistics, occupational diseases are classified into the following disease groups according to diagnosis and cause (for a detailed classification see Appendix 5 in ref [3]).

**Hearing loss** Noise-induced hearing loss refers to the deterioration of hearing due to prolonged exposure to noise or occasionally due to momentary impulse noise.

**Repetitive strain injury of upper limbs** A repetitive strain injury is a musculoskeletal disease caused by non-physiological stress at work (repetitive and monotonous work, unusual working postures).

1  
2  
3 The group includes tenosynovitis, peritendinitis, epicondylitis, bursitis, and mononeuropathy (e.g.  
4 carpal tunnel syndrome) of the upper limbs.  
5  
6

7 **Allergic respiratory diseases** Allergic respiratory diseases include asthma, allergic rhinitis, allergic  
8 alveolitis, and chronic laryngitis.  
9  
10

11 **Skin diseases** Occupational skin diseases are caused by chemical agents or micro-organisms in the  
12 work environment; the most significant diseases in this group are irritant contact dermatitis and  
13 allergic contact dermatitis.  
14  
15

16 **Asbestos-induced diseases** The group includes all occupational diseases caused by asbestos –  
17 pleural plaques, adhesions and calcifications being the most frequent. Lung cancer and asbestosis  
18 are the most severe diseases in this group.  
19  
20  
21

22 **Others** The group includes, for example, infectious diseases, conjunctivitis, hand-arm vibration  
23 syndrome, and various types of poisoning, including solvent-induced encephalopathy.  
24  
25  
26  
27  
28  
29

## 30 RESULTS

31  
32  
33

34 Altogether, 240,000 cases of suspected and recognized ODs were analysed. Annual average rates  
35 varied from year to year. The total number was 25.0/10,000 employees in 1975 and 20.1/10,000  
36 employees in 2013. From 1975 to 2013, the Finnish workforce increased from 2.1 million to 2.6  
37 million. Figure 2 presents the time trends of different disease groups from 1975 to 2014. The arrows  
38 indicate important incidents/events that have had an influence on incidence rates.  
39  
40  
41  
42  
43  
44

45 Figure 3 presents the rate ratios of ODs in different fields of industry for 1975–2013. The highest rate  
46 ratio was in mining and quarrying (9.87; 95%CI 8.65–11.30) and construction (9.11; 95%CI 7.98–  
47 10.43), when the reference group was financial and insurance activities (RR=1.00).  
48  
49  
50  
51  
52

53 There is a distinct decreasing trend in ODs from 2005 onwards: the average annual change in  
54 incidence was, for example, -9.2% in agriculture, -10.3% in transportation, and -4.7% in construction  
55 (see Table 1).  
56  
57  
58  
59  
60

The annual incidence rate of all notified cases declined from 31/10,000 employees in 2005 to 20/10,000 employees in 2013. The reduction in the incidence rate of recognized occupational diseases is more distinct than that of suspected cases: the annual incidence of recognized cases declined from 16/10,000 employees to 8/10,000 employees, while the annual incidence of suspected cases dropped from 16/10,000 employees to 12/10,000 employees. The average annual decline was greatest in upper limb strain injuries (-11.1%; see Table 2).

Table 1. Annual number and average incidence rate (95 % CI) per 10,000 employees, and average percentage change and 95% confidence interval in incidence of occupational disease in Finland for 2015–2013 by field of industry.

Field of industry	Recognized ODs (2005–2013)		Suspected ODs (2005–2013)	
	Annual average incidence rate (95% CI) per 10,000 employees	Annual average percentage change in incidence (95% CIs)	Annual average incidence rate (95% CI) per 10,000 employees	Annual average percentage change in incidence (95% CIs)
A Agriculture	39.5 (30.8, 48.1)	- 9.2 (-10.2, -8.2)	31.2 (24.5, 37.9)	- 9.8 (-11.0, -8.6)
B Mining	35.4 (29.8, 41.0)	- 4.8 (-8.1, -1.5)	22.2 (18.3, 26.0)	- 10.2 (-4.2, -16.1)
C Manufacturing	26.0 (22.6, 29.3)	- 4.5 (-4.9, -4.1)	24.6 (23.2, 26.0)	- 0.7 (-0.9, -0.5)
F Construction	29.9 (26.4, 33.3)	- 4.7 (-5.4, -4.0)	19.8 (17.6, 22.0)	- 0.3 (-0.5, -0.09)
Others	7.0 (6.0, 7.9)	- 5.7 (-6.2, -5.2)	9.6 (8.9, 10.3.9)	- 2.6 (-3.2, -2.0)
<b>Total</b>	11.7 (9.8, 13.6)	- 6.7 (-7.0, -6.4)	13.5 (12.5, 14.6)	- 2.8 (-3.0, -2.6)

Table 2. Annual number and average incidence rate (95 % CI) per 10,000 employees, and percentage change and 95% confidence interval of recognized and suspected occupational diseases in Finland for 2005–2013.

Occupational disease	Recognized ODs (2005–2013)			Suspected ODs (2005–2013)		
	Number of cases	Annual average incidence rate (95% CI) per 10,000 employees	Annual average percentage change in incidence (95% CIs)	Number of cases	Annual average incidence rate (95% CI) per 10,000 employees	Annual average percentage change in incidence (95% CIs)
Hearing loss	8,299	4.0 (3.2, 4.8)	- 8.1 (-8.7, -7.5)	4,542	2.2 (2.0, 2.4)	1.2 (0.9, 1.5)
Repetitive strain injuries	3,093	1.5 (1.1, 1.9)	- 11.1 (-12.2, -10.0)	4,648	2.2 (1.6, 2.9)	- 13.2 (-14.2, -12.2)
Allergic respiratory diseases	1,896	0.9 (0.7, 1.1)	- 7.8 (-9.0, -6.6)	6,556	3.1 (2.8, 3.5)	2.8 (2.4, 3.2)

1							
2							
3							
4	Skin diseases	4,295	2.1 (1.7, 2.4)	- 6.5 (-7.2, -5.8)	5,988	2.9 (2.7, 3.0)	-0.1 (-0.2, -0.02)
5	Asbestos-induced						
6	diseases	5,330	2.5 (2.4, 2.7)	- 1.7 (-2.0, -1.4)	1,640	0.8 (0.7, 0.9)	0.0 (0, 0)
7							
8	Others	1,530	0.7 (0.5, 0.9)	- 11.1 (-12.7, -9.5)	4,752	2.3 (1.6, 2.9)	- 7.9 (-8.7, -7.1)
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							
51							
52							
53							
54							
55							
56							
57							
58							
59							
60							

## DISCUSSION

Our results indicate that there has been a remarkable year-to-year fluctuation in the incidence of occupational diseases due to various causes; the analysis of long-term trends is needed to understand the overall direction of the changes. In-depth analysis of the trends in different branches reveals the areas where more preventive efforts are needed.

### 1970s

The increase in the incidence of ODs in the 1970s coincided with the establishment of the six regional offices of the FIOH. The purpose of the regional offices was to support local workplaces and to educate OSH personnel. This became possible as the FIOH was granted judicial status in the 1970s and it started to receive annual funding from the state. The first act on FIOH action was passed in 1978 (159/1978).

Furthermore, the former voluntary occupational health care system became mandatory in Finland in 1978 (Act 743/1978). The increasing number of professionals in occupational health care is supposedly related to the increasing number of notifications of ODs, and thus the increasing incidence of ODs in the register. Gradually, over three years, all private and public organizations with at least one employee had to arrange occupational health services for their workers. Mandatory services included, for example, workplace surveys and medical health examinations for workers. The number of workers covered by occupational health services increased remarkably, from approximately 1.1 million in 1978 (60% of all employees), to 1.6 million (80%) in 1983, to 1.9 million (87%) in 2013 [7]. In addition, the number of health examinations increased, revealing more ODs, which consequently resulted in the increase in the incidence of ODs.

### 1980s

1  
2  
3 Since 1978, farmers' pension insurance has included mandatory accident insurance (MATA), which  
4 provides compensation for occupational diseases caused by agricultural work. Guidelines for  
5 farmers' occupational health care were provided to municipal health centres in 1984, and farm visits  
6 were fully compensated by the state (Act 859/1984). Several campaigns were launched to encourage  
7 farmers to utilize occupational health care services.  
8  
9

10  
11  
12 The Governmental Decree on the Ordinance on Occupational Diseases contains a list of physical,  
13 chemical, and biological factors and the diseases caused by these factors. Updates to this list have  
14 resulted in the recognition of new ODs. A substantial increase in strain-related upper extremity  
15 musculoskeletal disorders was brought about by the changes in Decree 67/1987. With this decree,  
16 epicondylitis and tendinitis of the forearm became compensatory if the condition resulted from  
17 repetitive and one-sided movement or movement that was unfamiliar to the worker.  
18  
19  
20  
21  
22

### 23 **1990s**

24  
25 Screening for asbestos-induced diseases in Finland was carried out from 1990 to 1992 as part of the  
26 FIOH's Asbestos Program. Altogether, 18,900 employees were examined, and 3,500 new  
27 asbestos-related ODs were diagnosed. Most of them were benign pleural changes/plaques, but  
28 there were also 800 cases of asbestosis. The number of asbestos related diseases reported to the  
29 register multiplied for years after the campaign [8].  
30  
31  
32  
33

34 The founding of a National Centre for Agricultural Health (NCAH) in 1999 was a further push to  
35 develop working conditions in farming and to encourage more farmers to utilize occupational health  
36 care.  
37  
38  
39

### 40 **2000s**

41  
42 From 2003, insurance institutions have sent data on new ODs and suspected ODs to the Workers'  
43 Compensation Center (TVK). The FROD obtains its information from the TVK and the Farmers' Social  
44 Insurance Institution, Mela. Before 2003, insurance institutions sent data directly to the FROD.  
45 Information from Regional State Administrative Agencies (given by physicians) can be used to  
46 complete the data on diseases in the FROD.  
47  
48  
49  
50

51 In Finland, insurance companies pay for the examinations of both suspected and recognized ODs.  
52 The insurance institutions' payment system changed in 2003, however; medical units could claim  
53 examination costs directly from insurance institutions. Prior to 2003, insurance companies paid  
54 yearly a sum of money to the state as compensation for the medical examinations of ODs conducted  
55 at municipal medical centres and hospitals.  
56  
57  
58  
59  
60

1  
2  
3 In Finland, manufacturing, mining and quarrying, construction, agriculture, forestry, and fishing have  
4 clearly had the highest incidence rates of ODs over the decades, although there has been a  
5 decreasing trend since 2005. They are all branches involving manual, physically demanding work,  
6 and several possible occupational exposures are common. Construction work is a good example,  
7 because it includes various health hazards, such as exposure to physical stress, dust, noise, and  
8 vibration. Construction workers have been shown to be at an increased risk of work-related ill health  
9 and injury both in Europe and globally [9]. They have an increased risk of cancer, respiratory  
10 diseases, musculoskeletal disorders, and injuries compared to the general population [10]. The  
11 incidence of skin neoplasia, contact dermatitis, musculoskeletal disorders, mesothelioma, lung  
12 cancer, pneumoconiosis, and other benign pleural diseases is also increased among construction  
13 workers compared to the rest of the working population [11]. The trends of ODs in the construction  
14 sector are not decreasing everywhere: significantly increasing trends in noise-induced hearing loss  
15 and work-related contact dermatitis were observed in the construction sector in the Netherlands in  
16 2010–2014 [12]. An examination of trends and patterns in occupational illnesses among construction  
17 workers from 1992 to 2014 in the USA showed that construction workers continue to face a higher  
18 risk of work-related musculoskeletal disorders [13].

19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31 The Finnish surveillance system has been considered comprehensive. In an evaluation of  
32 occupational disease surveillance in six EU countries the Finnish Register of Occupational Diseases  
33 was rated as one of the best ones [14]. Every physician is obligated to report diagnosed and  
34 suspected cases of ODs. FROD offers data on the incidence of ODs from 1964 onwards. Because the  
35 register is based on a compensation system, under-reporting is not a major problem. Nevertheless,  
36 some physicians may neglect to report occupational diseases. Moreover, not all physicians are  
37 trained in occupational medicine, and some may thus fail to connect diseases with working  
38 conditions. For these reasons, some occupational diseases may remain either undiagnosed or  
39 unrecorded. The period of interest was almost 40 years, so it impossible to take into account all  
40 variables, which have affected incidences of ODs. Some factors may be missing although we  
41 systematically have gone through all potential influential ones. The data are based on the numbers  
42 of ODs obtained from the insurance companies and they may contain some errors in classifications  
43 of diseases or occupations, which are not possible to correct afterwards. However, these are  
44 supposed to be rare exceptions in the large entity of data. No systematic information bias is likely,  
45 because the data of each year has been analysed and reported previously in annual reports. A  
46 limitation of this study is the fact that the data are mostly limited to the notifications of ODs to the  
47 insurance companies and thus they do not give a picture of all work related diseases.



1  
2  
3 Registries and occupational diseases differ considerably in various countries in terms of the criteria  
4 for registration and notification, statistical data provided, and legal context [14, 15]. Therefore,  
5 figures on ODs are not necessarily comparable between countries. The ability to compare would be  
6 beneficial for improving occupational health policies and facilitating coordinated research. A  
7 comparison of OD surveillance systems in the EU countries has been recently published in order to  
8 facilitate this work in the future [16].  
9

10  
11  
12  
13  
14 The direct comparison of trends in OD within Europe showed that reports of contact dermatitis and  
15 asthma were declining in most countries, which is consistent with the positive impact of European  
16 initiatives addressing the relevant exposures [17]. This finding is consistent with the results of the  
17 present study, although the largest decline we noted was in the numbers of upper limb  
18 musculoskeletal disorders.  
19

20  
21  
22  
23 The main reasons for the fluctuation of OD incidence rates in Finland include changes in legislation –  
24 such as the addition of new diseases to the list of occupational diseases – screening campaigns, and  
25 developments in technology and occupational safety and health.  
26

27  
28  
29 The decline in the incidence of ODs in 2005–2013 has occurred at the same time as changes in fields  
30 of industry have continued. The number of workplaces in manufacturing has declined as the number  
31 of service workplaces has grown. Some 48.3% of men were employed in manual work in 2005; by  
32 2013, the percentage had dropped to 45.5%. For women, the numbers were 22% and 17.5%,  
33 respectively [18]. These changes influence the annual number and incidence rate of ODs (Table 2),  
34 but the reduction is also true in most other fields of industry (Table 1). Both the number of people  
35 leaving the workforce on disability pensions and the frequency of occupational accidents have  
36 decreased. The largest reduction was seen in 2006–2014, when the annual number of new disability  
37 pensions diminished by 26% [19]. The total number of occupational accidents declined by 27% in  
38 2006–2013 [20]. We assume that these three phenomena can be connected to the improvement of  
39 working conditions and activities of occupational health services.  
40  
41  
42  
43  
44  
45  
46  
47

48 There is evidence that technical improvements and innovations in processes may decrease the  
49 number of ODs. For example, passivating chromate by adding iron (II) sulphate to cement markedly  
50 reduced the allergic contact dermatitis incidence among construction workers [21]. In addition, the  
51 end of the practice of using latex gloves resulted in a reduction in allergic contact dermatitis in  
52 health care workers [22, 23]. In the UK, a significant reduction in the incidence of short latency  
53 respiratory disease and asthma attributed to glutaraldehyde or latex coincided with changes in  
54 legislation, mandatory advice from the Medical Devices Agency, new exposure limits, and the  
55 removal of glutaraldehyde-based disinfectants from the market [24, 25].  
56  
57  
58  
59  
60

1  
2  
3 This study provides a useful overview of the status of occupational diseases in Finland over several  
4 decades. These data are a valuable resource for determining which occupations are at an increased  
5 risk and where preventive actions should be targeted. It is important to study the long-term trends  
6 in the statistics of occupational diseases to see the bigger picture beyond the year-to-year  
7 fluctuations.  
8  
9  
10  
11

## 12 **ACKNOWLEDGEMENTS**

13  
14 We wish to thank the many experts at the FIOH for their fruitful comments on this study. In  
15 particular, we wish to express our gratitude to our colleagues at the FROD, especially Lea Palo  
16 (long-term Research Secretary) and Ilpo Mäkinen for their proficiency in maintaining the high quality  
17 and reliability of the Registry.  
18  
19  
20  
21

22 Figure 1. Fitting the cases of occupational diseases and suspected cases of occupational diseases/  
23 10,000 employees for 1975–2013 in the Poisson regression model.  
24  
25

26 Fig. 2 Recognized and suspected occupational diseases in Finland. The five-year moving average  
27 from 1975 to 2013. The arrows indicate important events influencing incidence rates.  
28  
29

30 Fig 3. Rate ratios of recognized and suspected occupational diseases by field of industry in Finland in  
31 1975–2013. The reference group is financial and insurance activities (K), RR=1.00.  
32  
33

## 34 **Statements**

### 35 a. Contributorship statement

36  
37 PO: Primary investigator involved in the study design, study conduct and reporting. RS and JU: Co-  
38 primary investigators involved in the study design, data collecting and reporting. NT and JN: Co-  
39 investigators involved in statistical planning, data processing and reporting. SV and AS: Co-  
40 investigators involved in planning, data collecting, data processing and reporting.  
41  
42  
43  
44  
45

### 46 b. Competing interests

47  
48 None declared.  
49

### 50 c. Funding

51  
52 The Finnish Work Environment Fund funded the study (Project number 115142).  
53  
54

### 55 d. Data sharing statement

56  
57 Information of published data from Finnish Registry of Occupational Diseases is available on website  
58 of Finnish Institute of Occupational Health. No unpublished data are available.  
59  
60

e. Ethical approval statement

Ethical approval was not required for this type of study (register study, anonymous data).

## REFERENCES

1. European Commission. Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions on an EU Strategic Framework on Health and Safety at Work 2014-2020. Brussels, 6.6.2014 COM(2014) 332 final.
2. Policies for the work environment and well-being at work until 2020. Publications of the Ministry of Social Affairs and Health : 2011:14
3. Oksa P, Palo L, Saalo A et al. Occupational diseases in Finland in 2012. New cases of recognized and suspected occupational diseases. FIOH Helsinki 2014, 79p. [http://urn.fi/URN:ISBN 978-952-261-470-4](http://urn.fi/URN:ISBN%20978-952-261-470-4) (pdf)
4. Statistics Finland, Population 2005:4. [Suomen Virallinen Tilasto, Väestö 2005:4; Tilastokeskuksen PX-Web -tietojärjestelmästä, Työssäkäynti, "010 – Väestö alueen pääasiallisen toiminnan, sukupuolen, iän ja vuoden mukaan"] [http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin\\_vrm\\_tyokay/010\\_tyokay\\_tau\\_101.px/?rxid=e20431bb-9577-4ef1-9a1d-479c299dffe6](http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin_vrm_tyokay/010_tyokay_tau_101.px/?rxid=e20431bb-9577-4ef1-9a1d-479c299dffe6) (accessed 1 Feb 2018)
5. NACE Rev.2 <http://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF> (accessed 1 Feb 2018)
6. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>
7. Annual statistics. The Social Insurance Institution of Finland, Kela Statistics
8. Koskinen K, Rinne JP, Zitting A, et al. Screening for asbestos-induced diseases in Finland. *Am J Ind Med* 1996;30:241-51.
9. Watterson A. Global construction health and safety- what works, what does not, and why? *J Occup Environ Health* 2007;13:1-4.
10. Arndt V, Rothenbacher D, Daniel U, et al. Construction work and risk of occupational disability: a ten year follow up of 14 474 male workers. *Occup Environ Med* 2005;62:559–566.
11. Stocks SJ, McNamee R, Carder M, et al. The incidence of medically reported work-related ill-health in the UK construction industry. *Occup Environ Med* 2010;67:575-576.
12. van der Molen HF, de Vries SC, Stocks SJ, et al. Incidence rates of occupational diseases in the Dutch construction sector, 2010-2014. *Occup Environ Med* 2016;73:350-352
13. Wang X, Dong XS, Choi SD, et al. Work-related musculoskeletal disorders among construction workers in the United States from 1992 to 2014. *Occup Environ Med* 2017;74:374-380.
14. Spreeuwers D, de Boer AGEM, Verbeek JHAM, et al. Evaluation of occupational disease surveillance in six EU countries. *Occup Med (Lond)* 2010;60:509–516.

15. European Commission. Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions. Safer and Healthier Work for All - Modernisation of the EU Occupational Safety and Health Legislation and Policy. COM(2017) 12 Final. Brussels; 2017
16. Carder M, Bensefa-Colas L, Mattioli S et al. A review of occupational disease surveillance systems in Modernet countries. *Occup Med (Lond)* 2015;65:615-625.
17. Stocks SJ, McNamee R, van der Molen H, et al. Trends in incidence of occupational asthma, contact dermatitis, noise-induced hearing loss, carpal tunnel syndrome and upper limb musculoskeletal disorders in European countries from 2000 to 2012. *Occup Environ Med* 2015;72:294-303.
18. Leinonen T, Viikari-Juntura E, Husgafvel-Pursiainen K. Labour market segregation and gender differences in sickness absence: trends in 2005-2013 in Finland. *Annals of Work Exposures and Health* 2017, 1-12.
19. Sauni R, Kivekäs J, Uitti J. Uudet työkyvyttömyyseläkkeet ovat vähentyneet neljänneksen. *Suom Laakaril* 2015;70:3056-3057. [Finnish, no English Summary]
20. Statistics Finland. Occupational accidents statistics. <http://www.stat.fi/til/ttap/2013/index.html>; Appendix table 3 [Liitetaulukko 3. Palkansaajien työpaikkatapaturmat 1976–2013] ([accessed 1 Feb 2018](#))
21. Roto P, Sainio H, Reunala T, et al. Addition of ferrous sulfate to cement and risk of chromium dermatitis among construction workers. *Contact Dermatitis* 1996;34(1):43-50.
22. Turjanmaa K, Alenius H, Reunala T, et al. Recent developments in latex allergy. *Curr Opin Allergy Clin Immunol* 2002;2:407-12.
23. Turner S, McNamee R, Agius R, et al. Evaluating intervention aimed at reducing occupational exposure to latex and rubber glove allergens. *Occup Environ Med* 2012;69:925-931.
24. Stocks SJ, McNamee R, Turner S, et al. Assessing the impact of national level interventions on workplace respiratory disease in the UK: part 1 – changes in workplace exposure legislation and market forces. *Occup Environ Med* 2013;70:476-482.
25. Stocks SJ, McNamee R, Turner S, et al. Assessing the impact of national level interventions on workplace respiratory disease on the UK: part 2 –regulatory activity by the Health and Safety Executive. *Occup Environ Med* 2013;70:483-490.

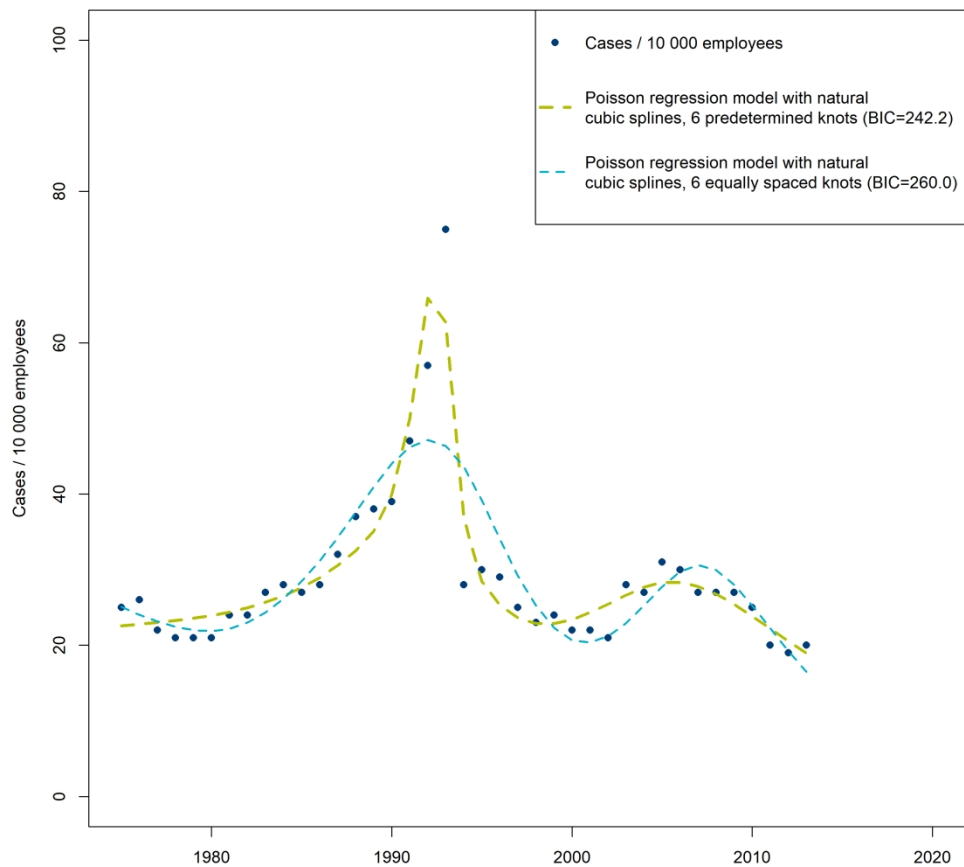
Figure 1. Fitting the cases of occupational diseases and suspected cases of occupational diseases/10,000 employees for 1975–2013 in the Poisson regression model.

Fig. 2 Recognized and suspected occupational diseases in Finland. The five-year moving average from 1975 to 2013. The arrows indicate important events influencing incidence rates.

1  
2  
3 Fig 3. Rate ratios of recognized and suspected occupational diseases by field of industry in Finland in  
4 1975–2013. The reference group is financial and insurance activities (K), RR=1.00.  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

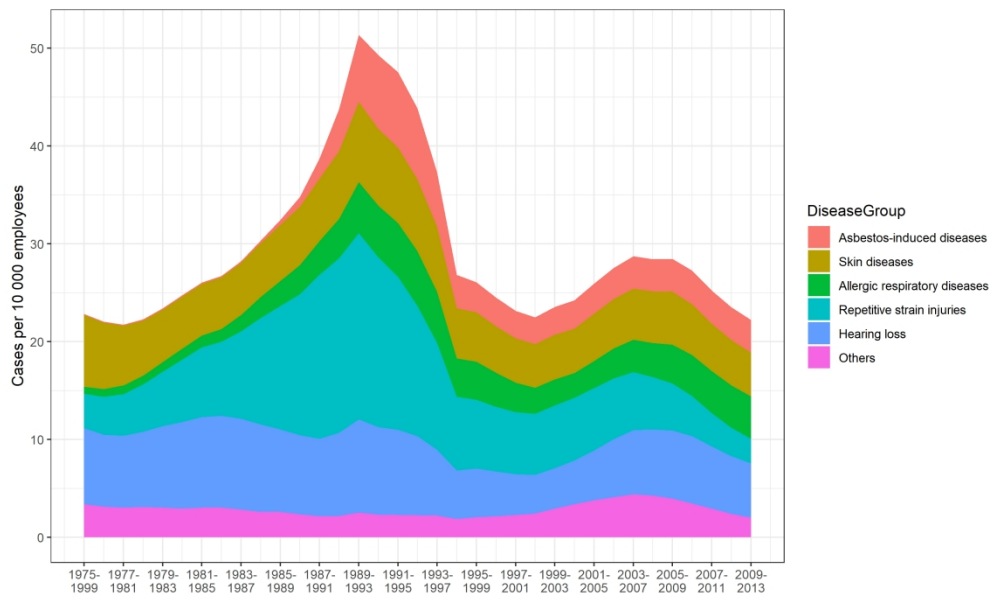
For peer review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



Fitting the cases of occupational diseases

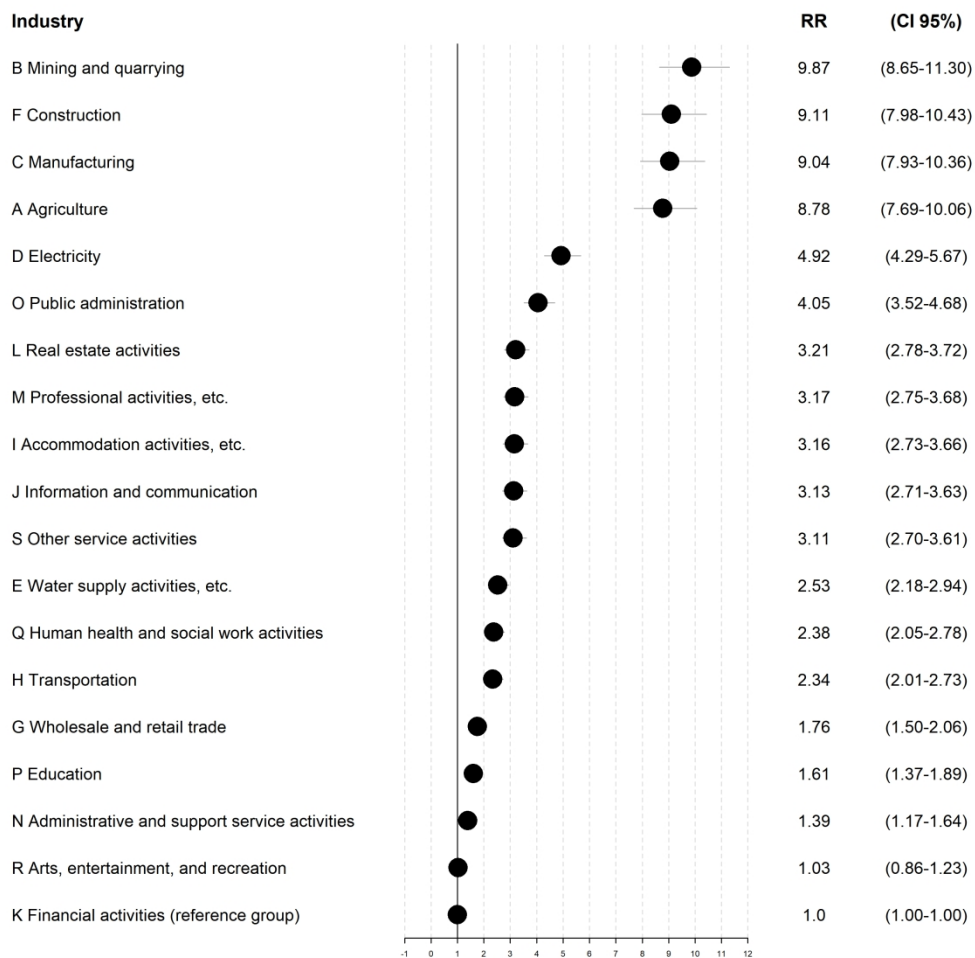
254x254mm (300 x 300 DPI)



Recognized and suspected occupational diseases in Finland.

254x152mm (300 x 300 DPI)

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



Rate ratios of recognized and suspected occupational diseases.

254x254mm (300 x 300 DPI)



Completed reporting checklist/ Trends in occupational diseases in Finland, 1975-2013 by Oksa P et al. /26 June 2018

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found PAGE 2
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported PAGE 4
Objectives	3	State specific objectives, including any prespecified hypotheses PAGE 5
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper PAGE 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection PAGES 5,6
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case PATIENTS WERE NOT INVOLVED
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable PAGES 5, 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group PAGES 5, 6
Bias	9	Describe any efforts to address potential sources of bias PAGE 5
Study size	10	Explain how the study size was arrived at ALL CASES WERE INCLUDED
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why PAGE 6
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding PAGE 6 (b) Describe any methods used to examine subgroups and interactions PAGE 6 (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

sampling strategy

---

(e) Describe any sensitivity analyses

Continued on next page

For peer review only

**Results**

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

**Discussion**

Key results	18	Summarise key results with reference to study objectives PAGE 9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias PAGE11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence PAGE11
Generalisability	21	Discuss the generalisability (external validity) of the study results PAGE 12

**Other information**

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based PAGE13
---------	----	--

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).