OCCUPATIONAL DISEASES IN THE AUTOMOTIVE INDUSTRY FROM MEDICAL AND GEOGRAPHIC VIEWPOINTS – COMPARISON BETWEEN THE CZECH REPUBLIC AND THE SLOVAK REPUBLIC

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SUMMARY

Objective: The aim of the study was to compare the occurrence of occupational diseases (ODs) in the automotive industry in the Czech Republic and the Slovak Republic and to analyze their determinants.

Methods: The aggregated and anonymized data on ODs from the period 2001–2017 were used. A questionnaire survey was conducted in the Czech Republic (response rate 70.6%) and in the Slovak Republic (response rate 57%). The occurrence of ODs according to socioeconomic factors, the size of enterprises and their position in the global production networks was evaluated. The quality and scope of the occupational health services were also taken into consideration.

Results: Workers older than 40 years were at a significantly higher risk of ODs than the younger ones. In the Czech Republic, it corresponded to OR 2.77 (95% CI 2.41–3.19), in the Slovak Republic to OR 2.01 (95% CI 1.34–3.01). The risk of ODs in women was significantly higher than in men – in the Czech Republic it corresponded to OR 3.20 (95% CI 2.79–3.67), in the Slovak Republic to OR 2.43 (95% CI 2.05–2.87). The difference between the two states did not reach statistical significance in any of the studied factors. In both states, no ODs were reported from the microenterprises.

Conclusion: Given the results of the study, it can be recommended to focus on the ergonomics of assembly work in the automotive industry. Special attention should be given to the provision of occupational health services, especially in microenterprises.

Key words: occupational diseases, automotive industry, health geography, incidence

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INTRODUCTION

The importance of studies on occupational health and safety is increasing, despite the fact that the available data are often heterogeneous, complex, non-structured, and very difficult to collect. This applies not only to the national/regional level, but also to the microlevel (e.g. individual enterprises) (1, 2). Various specialists analyze and evaluate the data from their particular standpoint. The aim of our study was to combine the medical and geographical viewpoints and to use modern imaging methods, namely geographic information systems, which are applied more often to study the regional variability in the occurrence of factors influencing workers' health (1–3).

It is generally accepted that the quality of work conditions influences the health of workers and the occurrence of occupational diseases (ODs) (4–8). Many authors studied the occurrence of ODs with respect to gender and age of workers (9–11). ODs have a negative impact both on the affected individuals and on society while being preventable at the same time.

In the Czech Republic (hereinafter Czechia) the long-term decreasing trend of the occurrence of ODs has been observed. This applies both to the absolute number of the reported OD cases and to the relative incidence. One significant exception is the automotive industry, where the significant increase in ODs is remarkable (12–14). The same has occurred in the Slovak Republic (hereinafter Slovakia), which ranks first in the world according to the production of automobiles per inhabitants (15).

The aim of our study was to compare the situation concerning the occurrence of ODs in the automotive industry (classification NACE Division 29) in Czechia and Slovakia. The situation is similar in many aspects in the two states. In both of them, the automotive industry represents the key sector of the economy.

In Czechia, it participates in the total industry production with about 25%; in Slovakia, it is 44%. Its share in the GDP represents 9% in Czechia and 12% in Slovakia. The share in total export represents 25% in Czechia and 35% in Slovakia (16, 17). In the whole European Union, a total of 12.6 million workers, i.e. 5.8% of the total EU workforce, are employed in the sector NACE 29, which produces 6.8% of the European GDP (18).

In 2018, a record number of automobiles were manufactured. In Czechia, a total of 1.437 million automobiles were produced, i.e. 135 automobiles per 1,000 inhabitants. In Slovakia, it was 1.001 million automobiles, which means 184 cars per 1,000 inhabitants, the highest number not only in Europe but worldwide (15). For the sake of comparison, 25 cars per 1,000 inhabitants were manufactured in the EU 28 on average in the same year.

Various health impairments are considered as occupational diseases in various countries and time periods (12). Therefore, the definitions of ODs across countries differ. This hinders an international comparison of OD occurrence, despite the effort for harmonization made by EUROSTAT in the European Occupational Diseases Statistics project (EODS) (19). Nevertheless, the comparison between Czechia and Slovakia is possible and does make sense, thanks to the long common history and similar legislation.

In this study we tried to find answers to the two following questions:

- Are there differences between Czechia and Slovakia in the incidence of ODs in the automotive industry with respect to the size of enterprises and their position in the global production networks?
- Are there differences between Czechia and Slovakia in the incidence of ODs in the automotive industry with respect to the socio-demographic characteristics of workers (age, gender)?

MATERIALS AND METHODS

Data

In this study we extended our previous research covering the period of 2001–2014 and involving the Czech Republic only (14). Here we analyzed the situation in the years 2001–2017 both in Czechia and Slovakia. We utilized two sources of information. First, the data from the Czech National Registry of Occupational Diseases and from the database of the Slovak National Health Information Centre was obtained. OD cases which occurred in the economic activity under Division 29 of the NACE classification (manufacture of motor vehicles) were retrieved and divided according to the identification number of the enterprises where the diseases originated (13, 14). The other classification criterion was the size of the companies (number of employees) in terms of EU 2003/361/EC methodology.

For the second source of information we performed a questionnaire survey in Czechia and Slovakia in the same way (14). The position of the enterprises in the global production networks (GPNs) was established according to the methodology by Pavlínek and Janák (20) and Pavlínek et al. (21). In Czechia, 350 enterprises were addressed. Of them, 247 eventually joined in (response rate 70.6%). In Slovakia, 130 enterprises were contacted and 75 of them eventually took part in the research (response rate 57.7%). Table 1 gives the basic characteristics of the involved enterprises.

Besides the absolute counts of ODs, we also used the relative incidence of ODs calculated as the number of OD cases having occurred during a calendar year per 10,000 people working in the economic Division NACE 29.

Table 1. *Characteristics of 322 companies involved in questionnaire survey in Czechia and Slovakia*

Czechia	Number of companies	Employees of companies					Number of OD cases	Average monthly income (in €)
		Total	Women	Average age of women	Men	Average age of men		
Microenterprise	8	40	9	38.7	31	45.8	0	713.19
Small enterprise	54	1,446	412	42.8	1,034	42.2	2	844.42
Medium-size enterprise	77	9,944	4,054	40.1	5,890	39.7	42	992.03
Large enterprise	108	98,369	34,580	39.2	63,789	37.9	563	1,094.31
Total	247	109,799	39,055	40.2	70,744	41.4	607	
Slovakia	**Number of companies**	**Employees of companies**					**Number of OD cases**	**Average monthly income (in €)**
		Total	**Women**	**Average age of women**	**Men**	**Average age of men**		
Microenterprise	4	19	1	42.7	18	44.1	0	548.25
Small enterprise	10	403	57	39.0	346	41.5	1	665.10
Medium-size enterprise	26	3,386	1,147	40.6	2,239	40.9	13	744.25
Large enterprise	35	46,168	14,725	40.2	31,443	39.9	98	832.75
Total	75	49,976	15,930	40.6	34,046	41.6	112	

Data source: own survey (January – July, 2018)
The size of the companies was classified according to EU 2003/361/EC

Methods

Using a geographic information system (GIS), we represented the measure of the automotive industry concentration in individual districts of Czechia and Slovakia, as well as the localization quotient as one of the key geographic indices of the economic structure. The methodology of the localization quotient calculation is described by Jarolímek et al. (14). The map outputs were generated using software ArcMap version 10.3 or higher.

The relation between OD occurrence on one hand, and age or gender on the other, was tested by the chi-square test in the contingence table. Results were expressed as odds ratio (OR) with 95% confidence interval.

RESULTS

During the studied period of 2001–2017, a total of 1,587 ODs occurred in NACE 29 Division (the automotive industry) in Czechia, and 161 in Slovakia (22, 23). The proportion of ODs in the automotive industry in the total count of ODs dramatically increased in both countries. While in 2001, the share of ODs in NACE 29 in the total count of ODs in Czechia was only 1.72%, it was almost 15% in 2015. In Slovakia, there was an increase from 0.52% in 2011 to 8.19% in 2017 (Fig. 1).

Location Quotient of Automotive Industry in Administrative Districts in Czechia and Slovakia

Figures 2 and 3 represent the localization quotient (lq) of the automotive industry in Czechia and Slovakia in 2001 and 2011. In 2001, a total of 24 districts exceeded lq value 1.0, which means that the concentration of the automotive industry in those districts was above average. In Slovakia, the above-average concentration was found in 20 districts.

In 2011, the number of districts with a lq higher than 1.0 increased in both countries, specifically to 31 in Czechia and 28 in Slovakia. However, while the number of districts with an above-average concentration of the automotive industry increased, the extremely high lq values in the districts which were narrowly specialized in the industrial sector in 2001 decreased considerably. In Czechia, it was, for example, in Mladá Boleslav from 19.6 in 2001 to 9.8 in 2011 or in Nový Jičín from 7.0 to 4.0. In Slovakia in 2001, the highest lq value of 5.5 was observed in the district of Malacky, which decreased to 2.7 in 2011. In general, the localization quotients reached noticeably higher values in Czechia than in Slovakia, which means that the geographic concentration of the automotive industry was higher in Czechia than in Slovakia.

Socio-demographic Indicators and Occupational Diseases

In Czechia, 350 companies from the automotive industry were addressed, employing more than 140,000 workers. Of them, 247 returned completed questionnaires and were included in our study, which thus covered 109,799 employees (78% of all employees in NACE 29). The structure of involved companies according to their size (measured by the number of employees) was as follows: large enterprises 43.7%, medium-sized enterprises 31.2%, small enterprises 21.9%, and microenterprises 3.2%. The average salary was highest in the large enterprises (corresponding to € 1,094) and decreased parallelly to the decreasing size of the enterprises. The lowest average salary was in microenterprises (€ 713).

In Slovakia, we contacted 130 companies and received questionnaires from 75 of them. Thus, our data covered 49,976 employees (70% of all employees in NACE 29). The structure of the companies according to their size was as follows: large enterprises 46.7%, medium-sized enterprises 34.7%, small enterprises 13.3%, and microenterprises 5.3%. The situation concerning the average salary was similar to Czechia, the highest salary was reported in the large enterprises (€ 883), continually decreasing to the lowest one in microenterprises (€ 548).

In Czechia, 924 ODs, which originated in the 247 collaborating companies, were included in our research, representing 58.2%

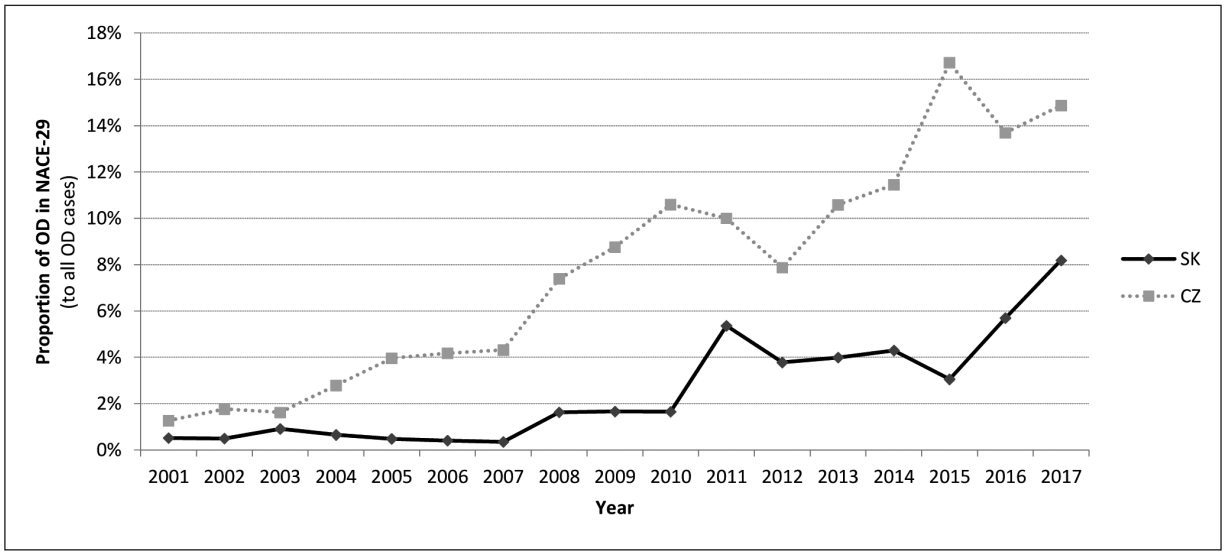

Fig. 1. *Proportion of ODs in NACE 29 Division (manufacture of motor vehicles) in all OD cases from 2001 to 2017 in Czechia and Slovakia.*

Data source: NIPH, 2018; NCZI, 2018

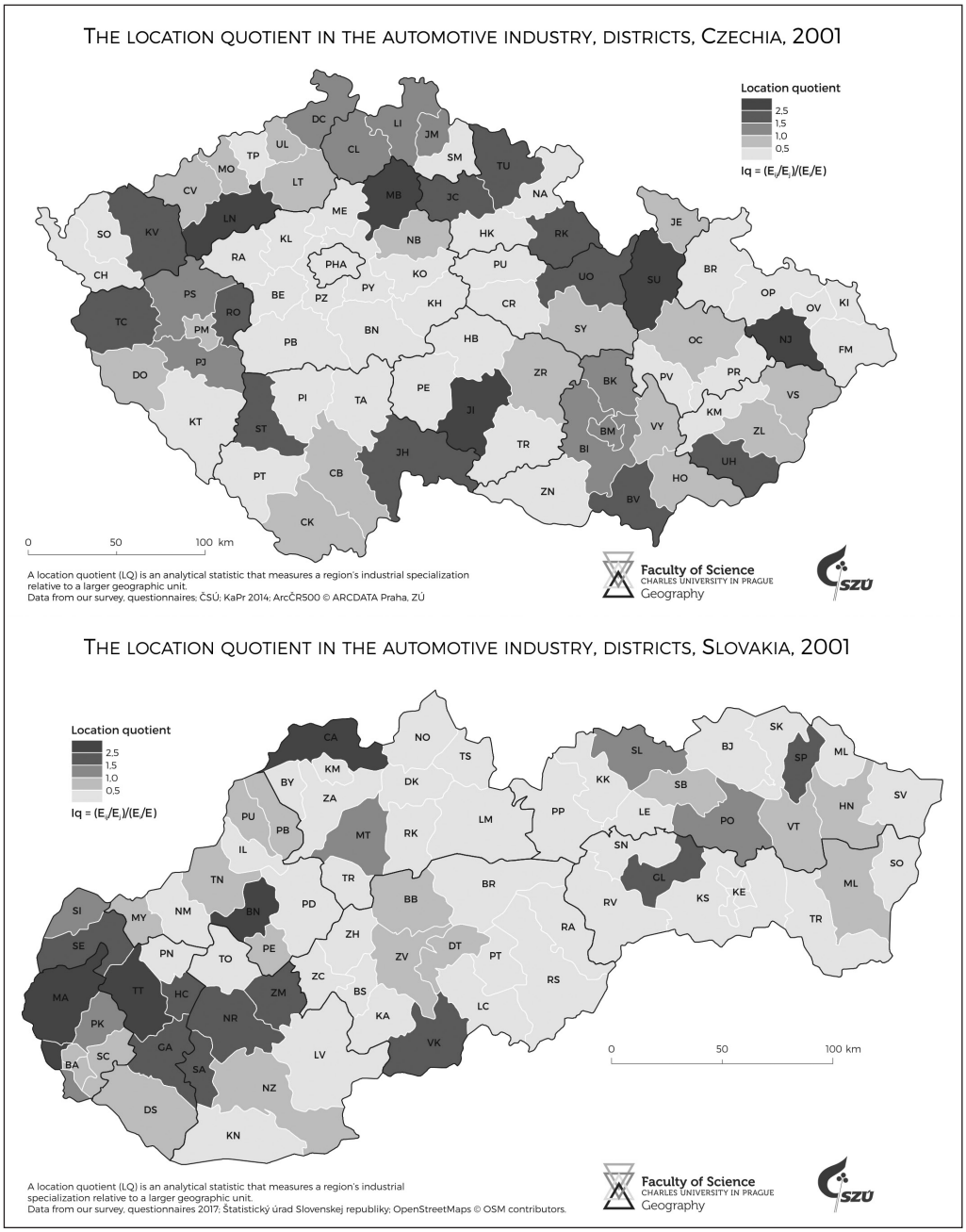

Fig. 2. *Localization quotients of automotive industry in districts of Czechia and Slovakia in 2001.*

of all ODs acknowledged in the automotive industry in Czechia during 2001–2017 (1,547 ODs). In Slovakia, there were 112 ODs in 75 collaborating companies, which represented 69.6% of all 161 ODs in NACE 29 during the studied period.

Age and Gender of Employees and Occupational Diseases

In both countries, the studied cohorts were divided according to age into two subgroups: ≤ 40 years and > 40 years. Some analyses were performed separately for men and women (Table 2).

The proportion of employees aged ≤40 years or >40 years in the studied groups was 58% vs. 42% in Czechia and 53% vs. 47% in Slovakia, respectively. On the other hand, in the subgroups of workers with an OD, the proportion of those aged ≤40 years or >40 years was 34% vs. 66% in Czechia and 36% vs. 64% in Slovakia, respectively. The difference corresponds to OR 2.77 (95% CI 2.41–3.19) in Czechia and to OR 2.01 (95% CI 1.34–3.01) in Slovakia.

If we divided the whole groups according to gender, the proportion of men vs. women was 64% vs. 36% in Czechia and 68% vs. 32% in Slovakia, respectively. By contrast, in the subgroups of workers with an OD, the proportion of men vs. women was 36% vs. 64% in Czechia and 46% vs. 54% in Slovakia, respectively. This corresponds to OR 3.20 (95% CI 2.79–3.67) in Czechia and to OR 2.43 (95% CI 2.05–2.87) in Slovakia. It implies that the risk of an OD in both countries is higher in women than in men. For both studied variables (i.e. age and gender), the risk of an OD is higher in Czechia than in Slovakia. However, the differences between the two countries are not statistically significant, as it is evident from the overlapping confidence intervals of means.

Table 2. *Age and gender of employees*

Characteristics		Czechia		Slovakia	
		OD cases in 2001–2017 (n)	Employees in 2017(n)	OD cases in 2001–2017 (n)	Employees in 2017 (n)
Age	≤40 years	312	64,076	40	26,322
	>40 years	612	45,723	72	23,654
	Total	924	109,799	112	49,976
Gender	Men	336	70,744	51	34,046
	women	588	39,055	61	15,930
	Total	924	109,799	112	49,976

Data source: own survey (January – June, 2018)
ODs in 247 companies involved in our survey in Czechia and in 75 in Slovakia.

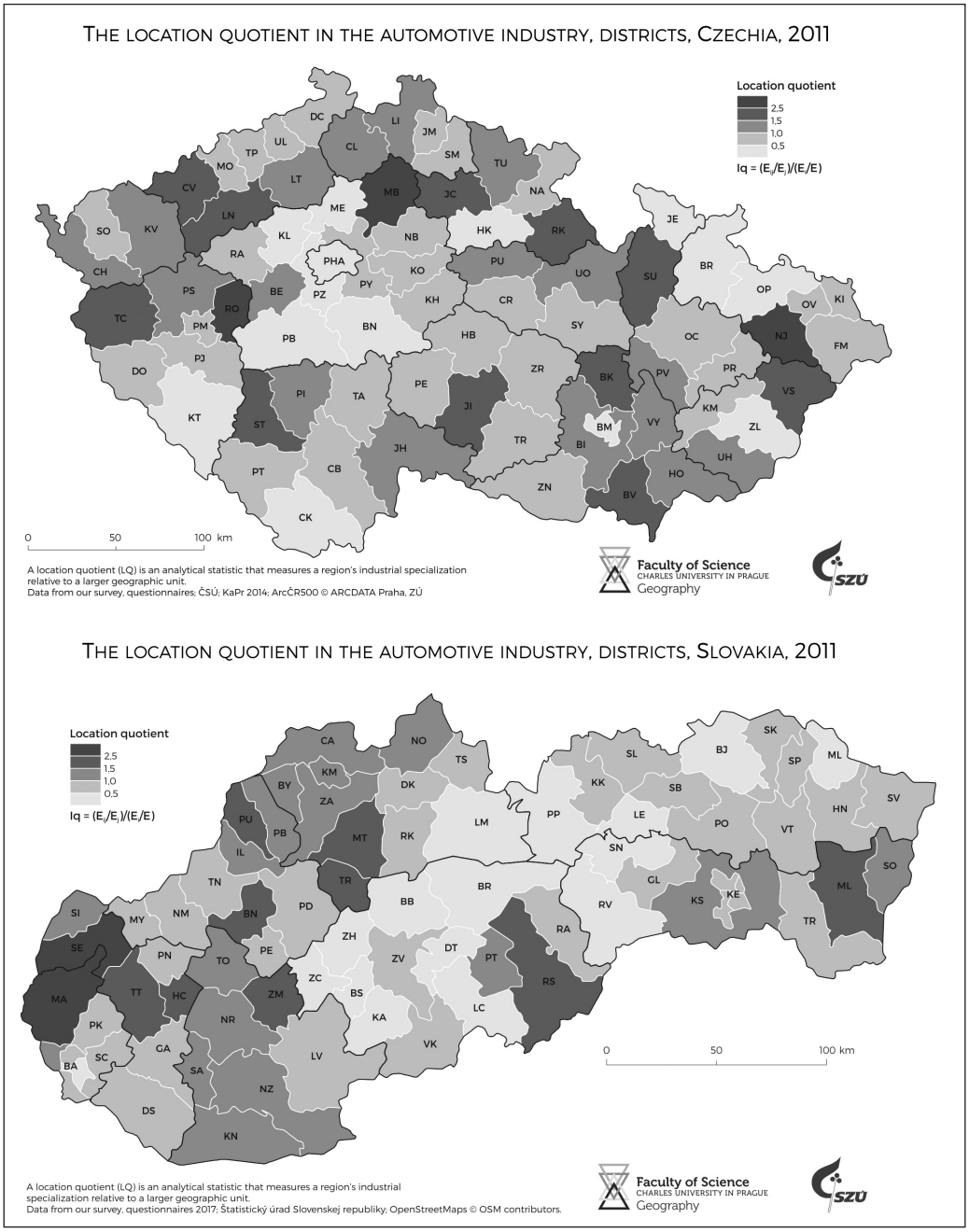

Fig. 3. *Localization quotients of automotive industry in districts in Czechia and Slovakia in 2011.*

Fig. 4a shows the incidence of ODs in the studied companies divided according to their size. In Czechia, a monotonous increase in the OD incidence rate parallel to the size of companies is evident. No such trend could be seen in Slovakia, where the highest incidence was in medium-sized enterprises. There were no ODs reported from microenterprises (less than 10 employees) in both countries.

Fig. 4b shows the OD incidence in the enterprises divided according to their position in the Global Production Networks (GPN) in 2017. The incidence in all types of enterprises was higher in Czechia than in Slovakia. The difference was marked in the supplier enterprises and minimal in the managing companies. In Czechia, the highest incidence was in the third tier suppliers, where large and medium-sized enterprises dominated. In Slovakia, it was the managing companies and the third tier suppliers, which were comprised mainly of large and medium-sized enterprises.

Quality and Scope of Occupational Health Services

The analysis of the questionnaire survey showed that in Czechia 97.2% of enterprises involved in our study provided for the occupational health services (OHS) in agreement with Law No. 373/2011 Coll. on the specific health services. It was done in 89.5% by external commissioned services and in 7.7% by internal employees. Only 2.8% of the enterprises did not arrange for any OHS. The analogous duty to provide OHS is prescribed in Slovakia by Law No. 355/2007 Coll., on protection, promotion, and development of public health. A total of 94.7% of the involved companies had the OHS arranged (of them 88.7% by external services and 11.3% by internal employees). Only 5.3% of the involved companies did not provide for OHS at all – most of them were microenterprises. This is in agreement with the statement in the EU Communication COM/2017/012 "Safer and Healthier Work for All" that only 69% of microenterprises report sufficient provision of OHS and regular evaluation of risk to health and safety of workers, in contrast to 96% of large enterprises.

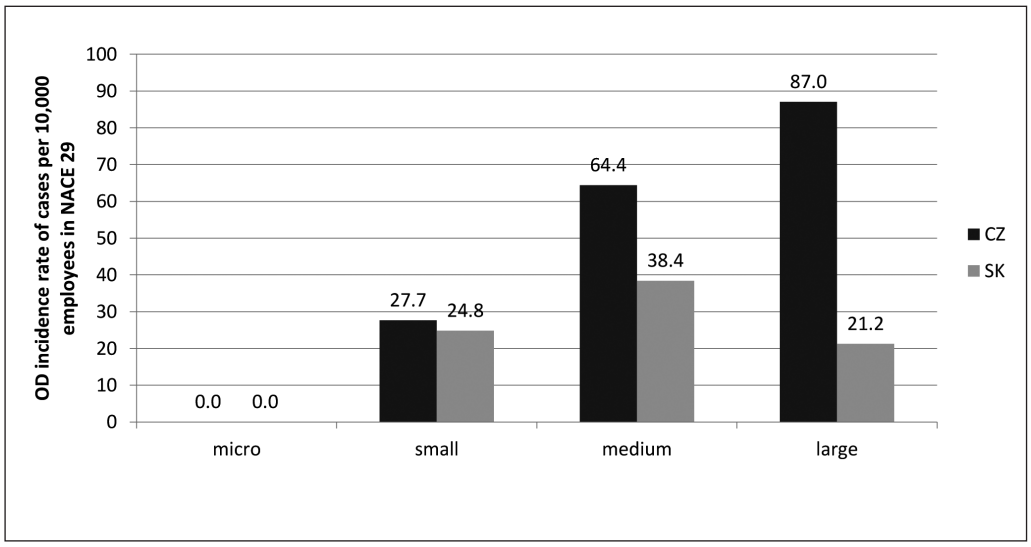

Fig. 4a. *Distribution of OD incidence rate according to company size.*

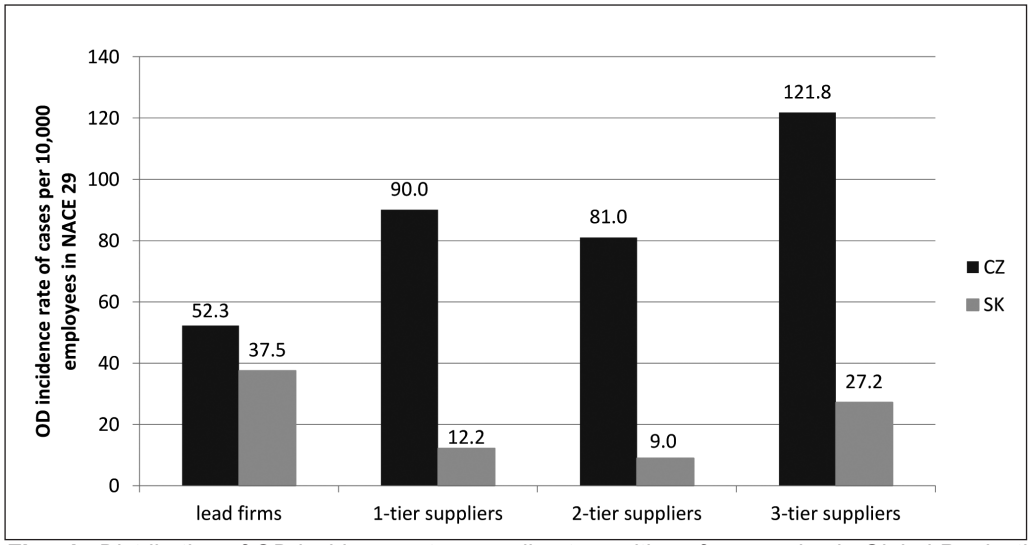

Fig. 4b. *Distribution of OD incidence rate according to position of companies in Global Production Networks in Czechia and Slovakia, 2017*

If a company provided OHS, we asked if the OHS involved workplace inspections in addition to preventive medical examinations. In Czechia 80% and in Slovakia 73% of the collaborating companies referred to the identification of hazards at workplaces and performed health risk assessment. More than 67% of companies in Czechia and 58% in Slovakia provided consultations to employers on occupational health and safety, occupational hygiene, ergonomics, and rules on the provision of personal protective equipment. About 50% of companies in both countries also took into consideration the assessment of accidents at work and occupational diseases. Additionally, we were interested in the satisfaction of employees with the OHS provided. However, only 20.6% of the collaborating enterprises in Czechia and 22.5% in Slovakia looked into this question.

The positive fact is that most enterprises had implemented systems for the prevention of occupational diseases – 94% in Czechia and 92% in Slovakia. Besides the obligatory pre-employment and pre-placement preventive examinations, they also frequently used various training courses and benefits programmes.

DISCUSSION

The aim of our study was to compare Slovakia and Czechia, two world powers in the manufacturing of automobiles per size of population, in the occurrence of ODs in the automotive industry, the key economic branch in both countries. Occupational diseases have negative impacts on the health of the affected individuals, as well as on the whole society. At the same time, they are preventable provided that effective preventive measures have been implemented.

We took into consideration the possible relation of OD incidence to the size of enterprises and to their position in global production networks. Furthermore, we analyzed the relation of OD incidence to various socioeconomic characteristics of employees. Our data shows a noticeable increase in the incidence of ODs during the studied period of the years 2001–2017 in both countries (22–23).

In that period, a total of 1,587 OD cases were acknowledged in NACE 29 in Czechia and 161 in Slovakia. The strikingly lower count of ODs in Slovakia has more causes. One of them is the difference in the methodology of reporting the most frequent ODs, namely the musculoskeletal diseases. In contrast to Czechia, various diseases affecting bones, joints, tendons and nerves are reported in Slovakia as one occupational disease – item 29 of the List (Diseases caused by long-term and stereotyped overload of the extremities). Similarly, the impairments of various organ systems caused by local vibration are reported as one disease – item 28 of the List (Diseases caused by vibration). Musculoskeletal disorders caused by overload or vibration represent most cases of ODs occurring in NACE 29. Actually, those diseases are the most frequent ODs in both countries. Within the EU, they represent about 60% of all work-related health problems (24), which makes them big health and socioeconomic issues. Ergonomic risks are the principal cause of MSDs.

We have focused on two socioeconomic factors: age and gender. As for age, bimodal distribution of the OD incidence is typically described. The first peak is usually in young workers, soon after they have entered into the working process. The lack of experience and correct working habits increases the probability of damage to their health. The second peak of the OD incidence is in the fifth and sixth life decades. This phenomenon is due to the physiological decrement of physical strength and mental abilities, and to the gradual exhaustion of the compensation mechanisms (11, 12). We observed a significantly higher incidence of ODs in workers aged above 40 years in comparison with the younger ones, both in Czechia (OR 2.77) and Slovakia (OR 2.01). The difference between the two countries did not demonstrate statistical significance.

As for gender, the occupational hazards for women have been underestimated on a long-term basis (24). Efforts to gender-neutral politics have contributed to the neglection of specifics associated with occupational health and safety in women. Physical strength in women is on average one-third lower than in men (25). It follows that men are constitutionally better equipped for physical loads and tolerate them better than women. The physiological capacity of the musculoskeletal system in women is easily overpowered by physical work with consequent health damage. Therefore, the incidence of ODs due to physical overload is higher in women than in men. The results of our study are in agreement with that knowledge. It appeared that the risk of ODs in women working in the automotive industry was significantly higher than in men (OR 3.20 in Czechia and 2.43 in Slovakia). The difference between the two countries did not show a statistical significance.

We further analyzed ODs in relation to the position of companies in the global production networks. In all types of companies, the incidence of ODs was higher in Czechia than in Slovakia. The difference was substantial in the supplier enterprises and minimal in the managing companies. This may be related to the structure of the various GPN tiers according to the size of enterprises. Ženka and Pavlínek (26) point out the specific situation of the third tier suppliers. These enterprises are in the most disadvantageous position in the whole GPN system. The managing companies and the first tier suppliers dictate to them what, when, and under which conditions they have to produce and supply. This pressure is offloaded onto employees. Such factories produce parts and components without higher added value and there is a high share of manual work. Those factors, along with high pace of production, bring overload to the musculoskeletal system of employees and higher morbidity.

Along with the increased incidence of ODs in the automotive industry, we also observed change in their structure in terms of shift to the musculoskeletal disorders. This is related to the exposure to physical overload and to the hand-arm vibration in less qualified workers due to insufficient robotization and automation of some working operations, especially where women are placed.

No ODs were reported from the microenterprises either in Czechia or Slovakia. In our opinion, this does not reflect reality. It is known from practice that the hygienic situation in microenterprises is usually worse than in bigger enterprises, so there are prerequisites for the occurrence of ODs. However, the level of OHS provision is low in the microenterprises and this decreases the probability of detection of any health impairment. In Czechia, about 2.8% of companies involved in our research did not provide for OHS; in Slovakia, it was 5.3%. The financial options, the technical and human resources, and the awareness and knowledge of occupational health risks are limited in small enterprises in comparison with the larger ones. The provision of

good OHS is considered crucial for prevention and detection of ODs (14, 27–29).

Our GIS analysis confirmed the high specialization in the automotive industry and the hierarchy of the suppliers' network in some regions in Czechia and Slovakia (20, 30). During the studied period, the automotive industry was decentralized and the number of districts specialized in this branch of industry markedly increased. The trend could be seen in both countries. The fact that a bigger part of the national economy in both countries is still becoming "dependent" on one type of industry is not unproblematic.

According to the Global Automotive Executive Survey (31), the share of the automobile production of Western Europe in the global production of cars will have decreased by 2030 from the current 15% to about 5%. The trend was already apparent in the previous decade, when employment in the automotive industry decreased in Western Europe, while it simultaneously increased in Central and Eastern European countries. This was associated with the continual transfer of car production to these regions. However, if Central and Eastern Europe will not substantially invest into research and development (RD), automation and artificial intelligence in the near future, vehicle production could be moved beyond Europe, possibly into Asia. The outdated factories will face the most danger because they will not be able to compete with the modern enterprises. The increase in the production costs and the decrease in the profit rate of the automobile factories in Western Europe and the USA lead them to relocate the production to cheaper, more advantageous regions. Pavlínek (32) calls such regions "the integrated peripheries".

Experts suppose that in 2040 the structure of car production will be as follows: electromobiles 30%, hybrid cars 25%, cars with combustion engines 24%, and hydrogen vehicles 21%. To keep in line with the trend, substantial investments into research and development will be necessary. Such investments are rather limited in Slovakia (32). The main hurdle for building RD centers in Slovakia is the lack of qualified staff. This represents one of the threats against the successful growth of the automotive industry – the high dependence on foreign capital, low domestic capacity, and the limited availability of qualified, technically educated specialists. The Czech Republic also has reserves in this point, although the volume of funds allocated to RD has doubled during the previous 10 years, up to 49 billion CZK in 2016. Despite this, the investment in RD compared to the GDP in Czechia (1.05% in 2015) is below the EU average (1.25%) (33). Even so, the automotive industry is one of the RD drivers in Czechia. Of the 49 billion CZK, 7.8 billion CZK were allocated in NACE 29. If we added the industry branches linked to the automotive industry (rubber-making, textile, and electrical and electronic engineering industries), then 10 billion CZK would be invested in this branch of economy.

Limitations

Despite our effort, our study has several limitations. One of them is the small number problem, which lowers the power of statistical tests and increases the probability of type II error. We assessed the ODs for the entire studied period in order to minimize the random error. However, this approach has shortcomings too as the numerator and denominator in the calculation of OD incidence was not always from the absolutely identical period. Therefore, the obtained results are burdened with some uncertainty.

CONCLUSION

According to our knowledge, an international comparison of the occurrence of occupational diseases in the automotive industry has not been published yet. Therefore, our study is unique from this aspect. Based on our results, we can recommend that the public authorities in the Czech Republic and the Slovak Republic focus their control activity on the ergonomics of workplaces in the automotive industry, especially on the assembly work, where the occurrence of occupational diseases due to physical overload is on a steady increase. We can further suggest concentrating on the employers' duty to provide comprehensive occupational health services. Special attention should be paid to the microenterprises, where no occupational diseases were officially reported either in the Czech Republic or the Slovak Republic.

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Authors' Contributions:

J. Jarolímek designed and conceived the study and drafted the manuscript. P. Urban retrieved and analyzed the data from the Czech Registry of Occupational Diseases. Ľ. Legáth interpreted the Slovak data.

Conflicts of Interests

None declared

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