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# Original papers

## A cross-national perspective on silicosis: incidence, occupational settings, and trends

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## Abstract

**Background**: Historically, silicosis is a disease of miners, but the last decade witnessed outbreaks in occupational settings not traditionally associated with silica exposure. Evidence from other countries may ground awareness and control of re-emergent risks.

**Methods**: Incident cases of occupational diseases, ranking and trends were analysed within 2012-2016, respectively within 2007-2016 for silicosis using a cross-national comparative study. Labor force profile and occupation were additional data used to identify similarities and differences between Romania and Israel. The incidence rates for silicosis extracted from the Global Burden of Disease Study 2017 were compared to national, continental, and global level.

**Results**: Between the two countries, the ratio was 1:1.5 for musculoscheletal disorders, 1:3 for respiratory diseases, 1:4 for noise-induced hearing loss, and 1:10 for silicosis. Regarding silicosis, three major diffences were found, namely: the burden of disease, the trend of incidence (ascending in Israel; descending in Romania), and the occupational setting (coal miner in Romania; artificial stone worker in Israel). Globally, Romania was among countries with high incidence of silicosis in 2017.

**Conclusion**: Silicosis was a national issue of concern at the time, but vigilance should continue, given the severity of this disease and the occurrence of other silica-related diseases.

**Keywords**: *occupational disease, silicosis, national, global*

## Introduction

Occupational diseases have ancient roots, but the current challenge is posed by the dynamic of industry and the characteristics of labor force. Thus, occupational epidemiological data are very helpful in risk assessment, in standard setting, and in policymaking, especially when an apparently elevated number of cases of disease occurs in a worksite [1]. Evidence is usually provided at national level by the Registry of occupational diseases. For example, in Romania this Registry is available since 1968 [2]; in Israel the document was set up in 2011 [3].

Silicosis is a severe occupational lung disease which continues to represent a public health as there is no effective early prevention, early diagnosis, and treatment [4]. For example, the global incidence of this disease was 23,700 patients in 2017 [5], while in Israel it was described an increasing prevalence at the time [6]. Some exposed individuals may be more susceptible than others to develop the disease, due to the genetic polymorphism of long non-coding RNA (lncRNA)-related single nucleotide [7]. Experimental studies confirm the early onset of oxidative damage in rats and culture cell model for silicosis, progressively evolving from the inflammatory stage to fibrosis [8, 9]. Cellular damage results mainly in the generation of free radicals and the release of cytokines [10]. Moreover, recent findings in models of lung fibrosis have suggested a major role for the NLRP3 (nucleotide-binding domain and leucine-rich repeat pyrin domain containing 3) inflammasome in silica-driven inflammation and fibrosis [11]. In lung diseases such as chronic obstructive pulmonary disease or idiopathic pulmonary fibrosis, oxidative stress was shown to be the secondary cause of pathology by promoting fibrogenesis through causing apoptosis of alveolar epithelial cells, activating myofibroblasts and inducing an inflammatory response [12].

The bioactivity of silica particles depends on their size, respectively respirable particles less than 5μm in diameter and nanoparticles [13]. Recently, an Israeli group identified the presence of nanosized silica particles, which are able to bypass alveolar clearance mechanisms and enter the bloodstream, potentially triggering extrapulmonary disease associated with several systemic autoimmune disorders [14]. Occupational exposure to respirable crystaline silica involves mining, industrial processes with abrasives / sandstones / sand / silica flour, Denim jeans production, dental material manufacturing, cement / brick / pottery manufacturing, ornamental / tomb / artificial stone fabrication and repair, shipbuiding, foundry, cutting semiprecious stones and gems, agriculture and construction [13]. Since the 2000s, the use of artificial stone became very popular worldwide. This composite material contains quartz with crystalline silica over 90%, coloured glass, shells, metals or mirrors bound together by a polymer resin [15]. Significant artificial stone silicosis outbreacks were subsequently reported from these new occupational settings, and especially from Israel, but also from Spain, Australia, and the United States.

This study outlines the occupational morbidity profile in Romania and Israel within the period 2005-2016, aiming to provide a rational perspective on similarities, differences, and trends. Hopefully, it aims to give a substantiate answer to the question "how occupational diseases are revealed in different countries".

## Material and method

A cross-national comparative study was designed for ranking and comparing the annual incidence of occupational diseases between two countries, namely Romania and Israel.

The starting point for our data mining was to find out the labor force profile, which currently has became comparable between the selected countries, but with significant differences in the past (2:1 ratio), as shown in Table 1.

**Table 1.** Labor force characteristics in Romania vs Israel

| Country | Working-age population (thousands) | | Employed persons (thousands) | |
|---|---|---|---|---|
| | *2016* | *2020* | *2016* | *2020* |
| Israel* | 6120 | 6634 | 4029 | 4131 |
| Romania** | 13263 | 8987 | 8449 | 4920 |

*Source: Central Bureau of Statistics and Bank of Israel computations

**Source: National Institute of Statistics, Bucharest

Medical data regarding occupational diseases were obtained from the National Institute of Public Health (Romania), respectively from official reports (Israel) [16-17]. Results were graphically displayed in the form of line chart to show the trend of occupational diseases over time, and in the form of column chart to compare values across the dominant diseases in the selected countries. The existence of differences - the only thing that is certain in comparative research issues - was analysed.

Silicosis, as the first-ranking disease in Romania at the time, was discussed in terms of occupational type of exposure, as well as in terms of incidence rates for silicosis in 2017 reported by the Global Burden of Disease Study [18], in order to integrate the local picture into a global one. Given the public health impact and complexities in preventing silicosis, we consider this approach will raise scientific interest for further research.

## Results

Regarding the new cases of occupational disease reported within 2012-2016, it can be noticed a different trend in both countries, as illustrated in Figure 1. Significant increasing trend occured in Israel since 2014.

**Figure 1.** The trend of occupational diseases, by the annual number of new cases

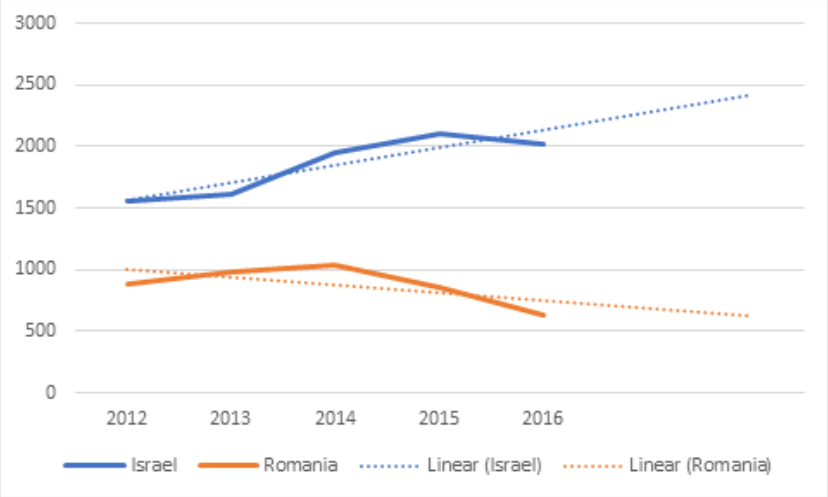
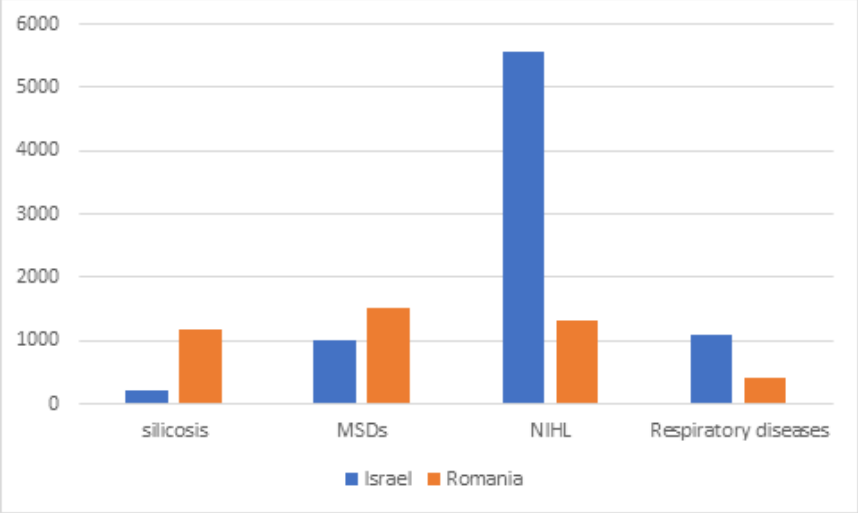



**Figure 2.** The ranking of occupational diseases, by the total number of new cases reported within 2012-2016



The effort to estimate the epidemiology of occupational diseases between countries is a difficult one and may cause uncertainties in the results. Thus, raw data used for ranking the dominant diseases in Romania and Israel were adjusted to the International Classification of Diseases 10th revision (ICD 10), according to the reporting model of Israel since 2012. According to ICD 10, chronic lower respiratory diseases (J40-J47) include bronchitis, COPD, asthma; musculoscheletal disorders – MSDs (M05-M79) include inflammatory polyarthropathies, arthrosis, other joint disorders, Sicca syndrome [Sjogren], dorsopathies, disorders of synovium and tendon, and other soft tissue disorders. The code for silicosis is J62-J62.9, respectively H833 for noise-induced hearing loss (NIHL). As may be observed in Figure 2, the dominant occupational disease in the five-year interval 2012-2016 was NIHL in Israel (4:1 ratio), while the share of MSDs tends to became similar in both countries (1:1.5 ratio), surpassing the historical dominance of silicosis in Romania. The burden of silicosis is the first major difference between Romania and Israel (10:1 ratio). Significant differences were also found in the incidence of chronic respiratory diseases (1:3 ratio).

**Figure 3.** Silicosis trends and forecasting, by the annual number of new cases within 2007-2016

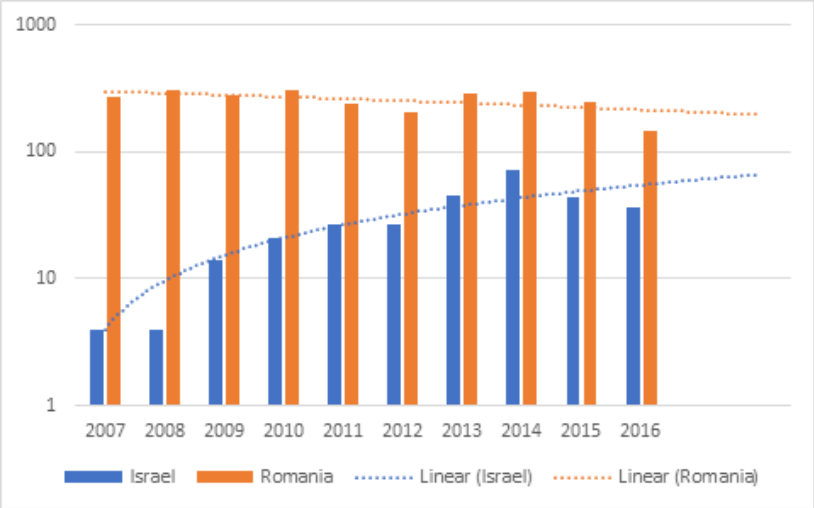



**Table 2.** The dominant occupational settings responsible for silicosis in Romania vs Israel

| Country | Economic sector | Activity | Occupation |
|---|---|---|---|
| Israel | Manufacturing / Construction | Artificial stone cutting | Manufacturing worker |
| Romania | Mining | Underground mining | Coal miner |

Focusing on the cases of silicosis reported by these countries within the period 2007-2016, we found the trend is ascending in Israel, in contrast to Romanian trend, as shown in Figure 3. Interestingly, Israel seems to experience a significant outbreak of silicosis, since 2012. The outcomes of silica exposure highlight two main occupational settings summarized in Table 2.

According to the age-standardized incidence rates (ASIR/100,000) for silicosis in 2017 reported by the Global Burden of Disease Study, Romania was among countries whith the highest incidence rate – see Table 3.

**Table 3.** The global picture of silicosis [18]

| Level | ASIR / 2017 | | | |
|---|---|---|---|---|
| | 0.4-0.8 | 0.2-0.4 | 0.1-0.2 | 0.06-0.1 |
| National | Romania<br>China<br>Chile | Israel<br>India<br>Venezuela | South Africa<br>Germany<br>Brazil | New Zealand<br>Canada<br>Russia |
| Continental | Asia | | Europe<br>South America<br>Africa | Australia |
| Global | 0.3 | | | |

## Discussion and conclusions

The five-year incidence of ocupational diseases in Romania and Israel follows opposite trends, respectively the incidence is forecast to increase in Israel. In epidemiological exposure-response models, the shape of the exposure-response curve arises an issue of concern for risk assessors; in our cross-national model this concern is obvious in the case of Israel after 2012, when silicosis outbreak raised scientific interest [19]. Moreover, silica exposure to 0.1 mg/m3/y is estimated to double the incidence of silicosis in Israel in 20 years [20].

In the past, silicosis was an issue of concern in Romania, but the second major difference occurs in trends and forecasting, respectively an ascending number of cases in Israel, in contrast to the incidence-reduction in Romania since 2010. This aparently decreasing trend of silicosis in Romania might be explained by a major shift in job exposure, coal mining sector becoming an almost extinct one [21, 22]. It is not surprising, since coal workers' pneumoconiosis displayed a decreasing trend worldwide [23]. Furthermore, the occupational setting was the third major difference resulted from comparative analysis. While in Romania crystalline silica exposure seems to remain the "old" hazard dominant in the mining activities, Israel and other countries have reported occupational clusters coming from the artificial stone manufacturing sector [24-27]. Subsequently, a newly emergent hazard alert was issued by the US National Institute of Occupational Safety and Health [28]. To our knowledge, artificial-stone silicosis was not reported in Romania, but the underground mining-worker is still the main occupation responsible for the new cases reported in 2021 (N=55), which probably are retired miners [29]. In this respect, Romanian specialists should take more action, in terms of awareness and risk management.

In the global picture of silicosis at the time, Romania was the only European country with high-risk level; Israel fits to the matrix of medium-risk, comparable to the global risk level; and, among continents, Asia has by far the highest incidence of silicosis due to China, the world's largest labor market. Recent findings show that two-thirds of global health loss from pneumoconiosis occur in China, with ASIR reaching up to 0.9-1.31 in certain provinces [30]. In this country, silicosis was the leading cause of disease burden from pneumoconiosis, showing an increasing trend of incident cases since 1990.

In conclusion, silicosis was the most prevalent confirmed occupational disease in Romania, but having different trends and sources of exposure when comparing to Israel. These findings suggest the disease is still a national and global health issue, and more effort is required to control known and emerging sources of silica exposure.

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