ORIGINAL ARTICLE

Hospitalizations of patients with sarcoidosis before and during the COVID-19 pandemic in Poland

Magdalena Bogdan[1], Krzysztof Kanecki[1], Piotr Tyszko[1,2], Piotr Samel-Kowalik[3], Paweł Goryński[4], Agnieszka Barańska[5], Aneta Nitsch-Osuch[1]

1 Department of Social Medicine and Public Health, Medical University of Warsaw, Warsaw, Poland
2 Institute of Rural Health in Lublin, Lublin, Poland
3 Department of Prevention of Environmental Hazards and Allergology, Medical University of Warsaw, Warsaw, Poland
4 National Institute of Public Health NIH – National Research Institute, Warsaw, Poland
5 Department of Medical Informatics and Statistics with E-learning Lab, Medical University of Lublin, Lublin, Poland

KEY WORDS

COVID-19, granulomatous disease, hospitalization, nationwide register

EDITORIAL

by Mejza and Mastalerz

ABSTRACT

INTRODUCTION Sarcoidosis is a multisystemic granulomatous disease that mostly affects the lungs and lymphatic system. Due to its rarity and variable clinical course, analyses of factors related to sarcoidosis should be based on large databases and long observation periods.

OBJECTIVES The aim of this study was to determine the characteristics of patients with sarcoidosis hospitalized in Poland over a long period (2016–2021).

PATIENTS AND METHODS We conducted a retrospective study using hospital discharge records compiled by the National Institute of Public Health NIH – National Research Institute. We analyzed the records of patients with sarcoidosis from the entire Polish population at their first hospitalization.

RESULTS We identified a total of 15 548 first-time hospitalizations for sarcoidosis. The mean annual disease incidence was 6.8 cases per 100 000. The mean (SD) age of the patients was 45.8 (13.6) years, and it was lower in men than in women (42.9 [12.5] vs 49.8 [14.2] years; $P < 0.001$). There were significantly more hospitalizations among city dwellers (62.3% vs 37.3% for rural residents; $P < 0.001$). At the beginning of the COVID-19 pandemic in Poland there was a decrease in the number of hospitalizations for sarcoidosis, followed by an increase in the subsequent year. The all-cause in-hospital death rate was significantly higher during the COVID-19 pandemic, as compared with the period before the pandemic (7.2 vs 2.3 per 1000; $P < 0.001$).

CONCLUSIONS Health care changes related to the outbreak of the COVID-19 pandemic may have increased the health debt for inpatient sarcoidosis treatment. The occurrence of sarcoidosis in Poland may be related to demographic and territorial factors.

Correspondence to:
Krzysztof Kanecki, PhD, Department of Social Medicine and Public Health, Medical University of Warsaw, ul. Oczki 3, 02-091 Warszawa, Poland, phone: +48 22 621 52 56, email: kanecki@mp.pl
Received: June 22, 2023.
Revision accepted: August 28, 2023.
Published online: January 2, 2024.
Pol Arch Intern Med. 2024; 134 (1): 16618
doi:10.20452/pamw.16618

INTRODUCTION Sarcoidosis is a multisystemic granulomatous disease, mostly affecting the lungs and lymphatic system. According to epidemiologic studies, there are significant variations in the disease frequency across countries, depending on age, sex, geographic region, and ethnicity.[1,2] A study from the United States[3] identified 37 688 individuals with sarcoidosis at a mean age of 50.5 years, 59.3% of whom were women. The prevalence of sarcoidosis in the United States was estimated at 35.22 per 100 000 population in a 7-year period.[3] Another American study indicated an annual disease incidence of 10 per 100 000 population.[4] In Canada, in the years 1996–2014, the incidence of sarcoidosis fell from 7.9 to 6.8 per 100 000 population. In 2015, the disease prevalence was 143 per 100 000.[5] The incidence rates vary significantly between different ethnicities; for example, in South Korea, they reach approximately 0.85 per 100 000,[6] whereas in black

WHAT'S NEW?

We present the latest data on hospitalization of patients with sarcoidosis, based on the national register of hospital morbidity covering an extended period from 2016 to 2021. The outbreak of the COVID-19 pandemic affected the inpatient care of this group of patients, as reflected by a decrease in the number of hospitalizations at the beginning of the pandemic, followed by an increase in the next year. Also, all-cause in-hospital death rate was significantly higher during the COVID-19 pandemic than before its outbreak. The study results suggest that the occurrence of sarcoidosis in Poland may be associated with demographic and territorial factors. Age, comorbidities, and the form of sarcoidosis may be related to the higher risk of COVID-19 among sarcoidosis patients. These findings may serve as a basis for comparative analyses with other countries.

women from across the United States, the annual incidence rate is 71 per 100 000.[7] In Sweden, the prevalence ranges from 152 to 215 per 100 000 population, depending on the definition used. The incidence is 11.5 per 100 000 per year and varies by –10% to +30%, depending on case definition.[8] The incidence and prevalence rates in Germany are 10 and 44–48 per 100 000 population, respectively.[9]

Prevalence of familial sarcoidosis is high in specific study populations across countries worldwide. Heritability at the level of 60% to 70% indicates that there is a shared determinant and a heterogeneous familial risk, which can be related to genetic and environmental factors.[10] Ethnicity can be related to particular disease phenotypes, which suggests a genetic predisposition of patients—erythema nodosum prevails in white patients, cardiac manifestations are more common in Japanese individuals, and other extrathoracic diseases are more frequent in black patients.[11] Etiopathogenesis of sarcoidosis is closely linked to environmental factors, especially occupational exposure.[12] Black and female patients, as well as those with a low socioeconomic status, exhibit increased hospitalization and mortality rates.[13] Peaks of sarcoidosis incidence can be related to the season of the year, and follow geographic North–South and West–East gradients. Lifestyle factors shown to be associated with the disease include smoking, household exposure, and leisure activities.[14] Geolocation, ethnicity, and living environment are major etiopathogenic factors.[15] In a study including data from a predominantly Caucasian population–based cohort from Olmsted County in Minnesota, it was suggested that sarcoidosis is less common in Caucasians than in Blacks, but more common in Caucasians than in Asians.[16] Clinical manifestations of the disease vary depending on sex.[17] Occupational exposure to silica dust seems to increase the risk of sarcoidosis among men aged 20 to 65 years. The risk is higher in exposed men at the age of 35 years or younger, and in older men with a longer time of exposure.[18] There was an increased risk of sarcoidosis post-9/11, in patients who had been working in the World Trade Center debris.[19] Nicotine treatment might reduce the disease progression.[20] On the other hand, ocular sarcoidosis is more frequent in active smokers.[21] Additionally, the risk of sarcoidosis may be higher among ever-smokers than in never-smokers who are exposed to silica dust.[22] Furthermore, infections that require hospitalization are more frequent in sarcoidosis patients.[23] The pathogenesis of sarcoidosis is not fully understood, and it may also be similar to that of other diseases, for example hypersensitivity pneumonitis.[24]

In our previous study,[25] covering the years 2008 to 2015, the average annual incidence rate of sarcoidosis in Poland was 7.5 per 100 000. The standardized incidence rates of total sarcoidosis were reported to range between 3.8 and 4.5 per 100 000 in a selected Polish population.[26] The highest number of sarcoidosis cases was diagnosed in individuals aged 35 to 54 years, and the disease was more frequently observed in men than in women.[27]

According to the World Health Organization (WHO) data, by the end of 2021, there were approximately 284 million confirmed cases of COVID-19 and 5.47 million COVID-19–related deaths in the world. In Poland, by the end of 2021, there were about 4.2 million confirmed cases of COVID-19, and 99 000 individuals died.[28]

The global variability of sarcoidosis incidence and its various clinical forms justify the need to obtain up-to-date data on the disease among hospitalized patients in Poland. The aim of this study was to determine the characteristics of hospitalized patients with sarcoidosis treated in Poland over a long period from 2016 to 2021.

PATIENTS AND METHODS In this retrospective study, we analyzed hospital discharge records of patients with a diagnosis of sarcoidosis. The data were obtained from the Polish National Institute of Public Health NIH – National Research Institute, and covered 39 988 hospitalization cases. Within this database, we analyzed records of patients at their first hospitalization for sarcoidosis. All hospitals in Poland, except psychiatric facilities, are legally required to send discharge data to the Institute. The data are anonymous and include information on hospitalizations with diagnosis codes according to the *International Classification of Diseases, 10th Revision* (ICD-10), dates of admission and discharge, birth date, sex, and place of residence. ICD-10 codes Z00–Z99 and R00–R99 were not taken into consideration. Groups of comorbidities occurring more frequently than in 5% of the study population were included in the analysis. We analyzed 2 groups: 1) all hospitalizations for sarcoidosis, and 2) first-time hospitalizations for sarcoidosis. To facilitate identification of the first-time hospitalizations, we considered data from our previous study.[25] We also obtained demographic data on the general Polish population from Statistics Poland.[29] We

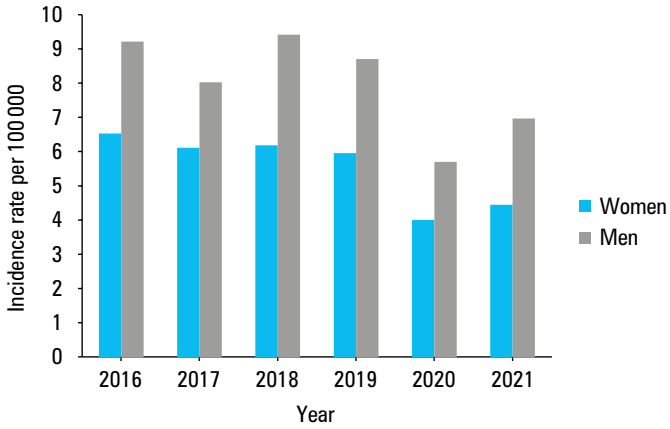

FIGURE 1 The annual incidence rate of hospitalizations for sarcoidosis in the years 2016 to 2021, stratified by year and sex

calculated incidence rates by using the number of patients with sarcoidosis and the corresponding census data. Sarcoidosis predominantly affects the lungs but it may also involve any other organ, and often requires advanced differential diagnostic procedures or treatment during hospitalization. Therefore, analysis of hospitalized cases may provide a good basis for estimating the disease incidence. We assumed that sarcoidosis diagnoses in hospitals were based on the most current and widely used criteria.

Statistical analysis To perform statistical analyses, we used Statistica version 13 (TIBCO Software Inc., Palo Alto, California, United States) and WINPEPI packages.[30] We computed means for continuous variables, and counts or percentages for categorical variables. Comparison of data was performed using the *t* test with respect to an assumption of normal distribution in sufficiently large samples in public health research.[31] WINPEPI packages were used when comparing the difference in population proportions between 2 groups. We estimated 95% CIs, assuming that the cases followed the Poisson distribution. We calculated prevalence and incidence rates by dividing the relevant numbers of sarcoidosis cases by the corresponding census figures. A 2-sided *P* value below 0.05 was considered significant. To illustrate the changes due to the outbreak of the COVID-19 pandemic, we made a comparison of selected demographic and territorial factors in the period before and after March 4, 2020.

RESULTS In the years 2016–2021, we identified 15 548 records of first-time hospitalization for sarcoidosis in the study population. The mean annual incidence was estimated at 6.8 per 100 000 (95% CI, 5.5–8). The highest number of cases was observed in 2016, with an incidence of 7.9 per 100 000, and the lowest in 2020, with an incidence of 4.8 per 100 000. The annual incidence rate of sarcoidosis hospitalizations by year and sex is shown in FIGURE 1.

There was a predominance of men in the study population (57.5% vs 42.5% of women; $P < 0.001$), as compared with the general population. The percentage of women did not differ before and during the COVID-19 pandemic (42.7% vs 41.8%; $P = 0.35$). The mean (SD) age in the study population was 45.8 (13.6) years, and men were significantly younger than women (mean [SD], 42.9 [12.5] years vs 49.8 [14.2] years; $P < 0.001$). The mean age of the patients hospitalized before and during the COVID-19 pandemic was significantly different (mean [SD], 45.6 [13.6] years vs 46.6 [13.8] years; $P < 0.001$).

Most of the hospitalized patients were urban dwellers (62.3% vs 37.3% of rural residents; $P < 0.001$); 64 patients (0.4%) did not identify their place of living, and there were no significant differences in the percentage of city dwellers before and during the COVID-19 pandemic.

In the analyzed period, a total of 53 deaths were reported (33 men, 20 women; mean age, 64 years). Among the deceased patients, 27 died in the prepandemic period, and 26 after the pandemic outbreak.

The all-cause in-hospital death rate was significantly higher during the COVID-19 pandemic than before (7.2 vs 2.3 per 1000; $P < 0.001$).

In the years 2016 to 2019, the most frequent forms of the disease were sarcoidosis of the lungs and lymph nodes (D86.2; 29.9%), sarcoidosis of the lungs without lymph node involvement (D86.0; 23.1%), unspecified sarcoidosis (D86.9; 19.8%), sarcoidosis of the lymph nodes (D86.1; 18.7%), sarcoidosis involving other sites and combined sites (D86.8; 4.4%), and skin sarcoidosis (D86.3; 2%). After the COVID-19 pandemic outbreak, in the years 2020–2021, the most common disease form was sarcoidosis of the lungs with lymph node involvement (D86.2, 31%), followed by sarcoidosis of the lungs without lymph node involvement (D86.0, 22.3%), unspecified sarcoidosis (D86.9, 20.4%), sarcoidosis of lymph nodes (D86.1, 18%), sarcoidosis involving other sites and combined sites (D86.8, 4.8%), and skin sarcoidosis (D86.3, 2%).

In the years 2016 to 2019, the 3 most frequent groups of comorbidities were diseases of the circulatory system (16.8%), diseases of the respiratory system (11.9%), as well as endocrine, nutritional, and metabolic diseases (10%). These were followed by diseases of the musculoskeletal system and connective tissue (5.6%), as well as other diseases that accounted for less than 5% of cases. After the pandemic outbreak, in the years 2020 and 2021, the top 3 groups of comorbidities included diseases of the circulatory system (18.1%), diseases of the respiratory system (11.6%), as well as endocrine, nutritional, and metabolic diseases (11.6%). These were followed by diseases of the musculoskeletal system and connective tissue (5.4%), as well as other diseases that accounted for less than 5% of cases.

We found 133 hospitalization records with codes related to COVID-19 (3.7% of all first-time hospitalization records since the beginning of the COVID-19 pandemic in Poland).

TABLE 1 Comparison of selected groups of comorbidities and forms of sarcoidosis in sarcoidosis patients with and without COVID-19, in the period after the COVID-19 pandemic outbreak

Groups of comorbidities by ICD-10 codes	Patients without COVID-19 (n = 3493)	Patients with COVID-19 (n = 133)	*P* value
Diseases of the circulatory system	602 (17.2)	53 (39.8)	<0.001
Diseases of the respiratory system	356 (10.2)	65 (48.9)	<0.001
Endocrine, nutritional, and metabolic diseases	398 (11.4)	26 (19.5)	0.007
Diseases of the musculoskeletal system and connective tissue	186 (5.3)	8 (6)	0.88
Forms of sarcoidosis by 5-character ICD-10 codes[a]			
Sarcoidosis of the lungs (D86.0)	754 (21.6)	55 (41.4)	<0.001
Sarcoidosis of the lymph nodes (D86.1)	644 (18.4)	10 (7.5)	0.002
Sarcoidosis of the lungs with sarcoidosis of the lymph nodes (D86.2)	1106 (31.6)	17 (12.8)	<0.001
Sarcoidosis of the skin (D86.3)	71 (2)	0	0.18
Sarcoidosis of other sites (D86.8)	171 (4.9)	5 (3.8)	0.69
Sarcoidosis, unspecified (D86.9)	707 (20.2)	32 (24.1)	0.28

Data are presented as number (percentage) of patients.

a Sarcoidosis was reported using only 3-character ICD-10 codes in less than 2.3% of patients.

Abbreviations: ICD-10, *International Classification of Diseases, 10th Revision*

Among the sarcoidosis patients hospitalized after the outbreak of the COVID-19 pandemic, the individuals with COVID-19 were significantly older than those without a COVID-19 diagnosis (mean [SD], 52.5 [13.6] vs 46.4 [13.7] years, respectively; P <0.001). More fatal hospitalizations were observed among the COVID-19 patients, as compared with those without a COVID-19 diagnosis (9% vs 0.4%, respectively; P <0.001). No significant sex-related differences were observed. Among the patients with sarcoidosis hospitalized after the outbreak of the pandemic, we found significant differences with respect to selected comorbidities and forms of sarcoidosis, as presented in TABLE 1. In another comparison of the 4 groups of diseases and forms of sarcoidosis listed in TABLE 1 between all patients in the periods before and after the outbreak of the COVID-19 pandemic, no significant differences in the incidence of these groups of diseases were observed, except a significant difference in the incidence of endocrine, nutritional and metabolic diseases (10.1% vs 11.7%, respectively; P <0.005).

DISCUSSION The incidence of sarcoidosis varies across countries and geographic regions. For example, the number of hospital admissions among patients with sarcoidosis in Spain increased 3-fold from 2001 to 2020.[32] In our study, the mean annual incidence in Poland in the years 2016 to 2021 was 6.8 per 100 000, which is comparable to the incidence observed for the years 2008 to 2015 (7.5 per 100 000).[25] The outbreak of the COVID-19 pandemic may have contributed to the disease incidence, as it may have been related to the number of hospitalizations of patients with sarcoidosis. In our study population, 3.7% of hospitalizations were assigned ICD-10 codes related to COVID-19 since the beginning of the pandemic in Poland. Additionally, moderate or severe impairment of the pulmonary function is related to mortality in sarcoidosis patients infected with SARS-CoV-2.[33] In our study, the patients with sarcoidosis and coexisting COVID-19 were significantly older than the other patients. In a large, multicenter cohort study from southern Europe, involving patients with SARS-CoV-2 infection and sarcoidosis, the age at the time of SARS-CoV-2 infection diagnosis was associated with an increased risk for hospitalization.[34]

Women were reported to be more frequently affected by sarcoidosis in selected regions,[5,15] whereas another study reported the predominance of male patients.[8] In our study, there was a predominance of men among the patients hospitalized for sarcoidosis, and there were differences in the average age between the groups of hospitalized men and women, which emphasized the influence of age and sex on the incidence of sarcoidosis in Poland. In a study from the United States, the peak age at incidence for women shifted from 40–59 years in 1950 to 50–69 years in 2010. Similarly, the peak age at incidence in men shifted from 30–49 years in 1950 to 40–59 years in 2010.[4] Another study, conducted in the years 2005–2018, identified 89 confirmed cases of sarcoidosis, 80.9% of which involved women, and the mean age at diagnosis was 46.8 years.[35] Sarcoidosis was not influenced by sex or age; however, it was more common in adults (<50 years) of African–American or Scandinavian descent.[36] In a study from South Korea,[6] the age distribution for incident cases in the entire population and in women indicated monophasic patterns that peak at the age of 50–59 years, whereas in men, biphasic patterns with incidence peaks at the age of 30–39 years and 60–69 years were observed.[6] In Sweden, the highest incidence was

observed in men aged 30–50 years and in women aged 50–60 years, and the mean age at diagnosis was lower among men than among women.[8]

In our study, most of the hospitalized patients were residents of urban areas. This is in in line with the findings of a Croatian study.[37] In another study, the highest sarcoidosis prevalence was observed in less densely populated areas of Sweden in the north-west.[8] More frequent hospitalizations of sarcoidosis patients living in urban areas may also result from better organization of and access to health care in cities. Accurate assessment of the causes of this difference, however, requires further research.

Sarcoidosis can affect any organ, with a frequency that depends on the sex and age of the patient. Intrathoracic involvement occurs in 90% of patients.[38] In our study, the distribution of sarcoidosis forms was similar before and after the COVID-19 pandemic outbreak. The pandemic may have had a little impact on the distribution of sarcoidosis forms, although this assessment was limited due to the reduction in the number of hospitalizations of sarcoidosis patients after the outbreak of the pandemic in Poland.

Sarcoidosis may be a risk factor for various comorbidities. In a study from Sweden,[39] individuals with sarcoidosis were at a higher risk of comorbidities and mortality than matched controls, as well as the general population of Sweden. In our study, the 3 most frequent types of comorbidities were diseases of the circulatory system; respiratory system; as well as endocrine, nutritional, and metabolic diseases. These were followed by diseases of the musculoskeletal system and connective tissue; and the distribution was similar before and after the pandemic outbreak.

Sarcoidosis may also be associated with the risk of death. In a Swedish cohort, individuals with incident sarcoidosis were at a higher risk of death, as compared with the general population.[40] However, in a study from the United States, the overall mortality of patients with sarcoidosis was not different from that of the general Minnesota population.[4] A study from France indicates that the hospitalization and mortality rates were higher in sarcoidosis patients with COVID-19 than in the general population.[41] In our study, only 53 deaths were reported in the analyzed period (0.34% of all cases), but approximately half of them occurred in the almost 2-year observation period after the COVID-19 outbreak in Poland. There were significant differences in age and fatal hospitalization rates among patients with sarcoidosis and COVID-19, as compared with those without COVID-19. Additionally, selected comorbidities or the form of sarcoidosis may have contributed to the higher risk for COVID-19 in the study population (TABLE 1). In a study based on questionnaire data from 5200 sarcoidosis patients, hazard ratios for SARS-CoV-2 infection were greater for those with pulmonary sarcoidosis and neurosarcoidosis, and a higher rate of hospitalization was found for those with underlying heart disease.[42] Moderate or severe impairment of the pulmonary function was reported to be associated with mortality in sarcoidosis patients infected with SARS--CoV-2.[33] Comorbidities, including hypertension, chronic lower respiratory tract diseases, diabetes mellitus, and ischemic heart disease, were more common in patients with pulmonary sarcoidosis than in those with nonpulmonary forms of the disease.[43]

On the other hand, in a study investigating potential risk factors for COVID-19 in sarcoidosis patients, no increased risk associated with age, sex, or major organ involvement was found.[44] A more precise assessment of the relationship between COVID-19 and sarcoidosis requires further research.

Study limitations Our study has several limitations. The hospital discharge database cointaned a relatively small number of available variables that could be analyzed in relation to hospitalizations for sarcoidosis. Also, the database only included discharge records of inpatient hospitalizations; therefore, patients with sarcoidosis who were treated on an outpatient basis were not included in the analysis. However, sarcoidosis is a systemic inflammatory disease with possible multiorgan involvement; as such, it may require treatment or advanced diagnostic procedures carried out in a short period of time that can only be performed in inpatient settings. Additionally, the date of the first-time hospitalization for sarcoidosis is not necessarily the date of the first diagnosis. This inaccuracy may have resulted in an overestimation of the incident cases. However, the long study period could have minimized the overestimation.

Conclusions At the beginning of the COVID-19 pandemic in Poland there was a decrease in the number of hospitalizations of patients with sarcoidosis; however, an increase was observed in the following year. The all-cause in-hospital death rate was significantly higher during the COVID-19 pandemic than before its outbreak. Health care changes related to the COVID-19 pandemic may have increased the health debt for inpatient sarcoidosis treatment. The study results suggest that the occurrence of sarcoidosis in Poland may be related to demographic, lifestyle, and territorial factors. Age, comorbidities, and the form of sarcoidosis may be related to the higher risk of COVID-19 among sarcoidosis patients.

ARTICLE INFORMATION

ACKNOWLEDGMENTS None.

FUNDING None.

CONTRIBUTION STATEMENT All authors conceived the idea for the study. All authors contributed to the design of the research. PG was involved in data collection. KK, PS-K, and MB analyzed the data. MB, PS-K, and KK edited the manuscript. PT and KK made a critical analysis of the article. All authors approved the final version of the manuscript.

CONFLICT OF INTEREST None declared.

HOW TO CITE Bogdan M, Kanecki K, Tyszko P, et al. Hospitalizations of patients with sarcoidosis before and during the COVID-19 pandemic in Poland. Pol Arch Intern Med. 2024; 134: 16618. doi:10.20452/pamw.16618

REFERENCES

1 Arkema EV, Cozier YC. Sarcoidosis epidemiology: recent estimates of incidence, prevalence and risk factors. Curr Opin Pulm Med. 2020; 26: 527-534.

2 Cozier YC. Assessing the worldwide epidemiology of sarcoidosis: challenges and future directions. Eur Respir J. 2016; 48: 1545-1548.

3 Nam HH, Washington A, Butt M, et al. The prevalence and geographic distribution of sarcoidosis in the United States. JAAD Int. 2022; 9: 30-32.

4 Ungprasert P, Carmona EM, Utz JP, et al. Epidemiology of sarcoidosis 1946-2013: a population-based study. Mayo Clin Proc. 2016; 91: 183-188.

5 Fidler LM, Balter M, Fisher JH, et al. Epidemiology and health outcomes of sarcoidosis in a universal healthcare population: a cohort study. Eur Respir J. 2019; 54: 1900444.

6 Yoon HY, Kim HM, Kim YJ, Song JW. Prevalence and incidence of sarcoidosis in Korea: a nationwide population-based study. Respir Res. 2018; 19: 158.

7 Cozier YC, Berman JS, Palmer JR, et al. Sarcoidosis in black women in the United States: data from the Black Women's Health Study. Chest. 2011; 139: 144-150.

8 Arkema EV, Grunewald J, Kullberg S, et al. Sarcoidosis incidence and prevalence: a nationwide register-based assessment in Sweden. Eur Respir J. 2016; 48: 1690-1699.

9 Costabel U, Wessendorf TE, Bonella F. Epidemiology and clinical presentation of sarcoidosis [in German]. Klin Monatsbl Augenheilkd. 2017; 234: 790-795.

10 Terwiel M, van Moorsel CHM. Clinical epidemiology of familial sarcoidosis: a systematic literature review. Respir Med. 2019; 149: 36-41.

11 Mateyo K, Thomeer M. Sarcoidosis around the globe. Semin Respir Crit Care Med. 2017; 38: 393-403.

12 Brito-Zerón P, Pérez-Álvarez R, Ramos-Casals M. Sarcoidosis. Med Clin (Barc). 2022; 159: 195-204.

13 Sharp M, Eakin MN, Drent M. Socioeconomic determinants and disparities in sarcoidosis. Curr Opin Pulm Med. 2020; 26: 568-573.

14 Ramos-Casals M, Kostov B, Brito-Zerón P, et al; Autoimmune Big Data Study Group. How the frequency and phenotype of sarcoidosis is driven by environmental determinants. Lung. 2019; 197: 427-436.

15 Brito-Zerón P, Kostov B, Superville D, et al; Autoimmune Big Data Study Group. Geoepidemiological big data approach to sarcoidosis: geographical and ethnic determinants. Clin Exp Rheumatol. 2019; 37: 1052-1064.

16 Ungprasert P, Crowson CS, Matteson EL. Epidemiology and clinical characteristics of sarcoidosis: an update from a population-based cohort study from Olmsted County, Minnesota. Reumatismo. 2017; 69: 16-22.

17 Singha A, Kirkland M, Drake W, Crouser ED. The influence of age and sex in sarcoidosis. Curr Opin Pulm Med. 2022; 28: 307-313.

18 Graff P, Larsson J, Bryngelsson IL, et al. Sarcoidosis and silica dust exposure among men in Sweden: a case-control study. BMJ Open. 2020; 10: e038926.

19 Jordan HT, Stellman SD, Prezant D, et al. Sarcoidosis diagnosed after September 11, 2001, among adults exposed to the World Trade Center disaster. J Occup Environ Med. 2011; 53: 966-974.

20 Crouser ED, Smith RM, Culver DA, et al. A pilot randomized trial of transdermal nicotine for pulmonary sarcoidosis. Chest. 2021; 160: 1340-1349.

21 Ronsmans S, De Ridder J, Vandebroek E, et al. Associations between occupational and environmental exposures and organ involvement in sarcoidosis: a retrospective case-case analysis. Respir Res. 2021; 22: 224.

22 Jonsson E, Järvholm B, Andersson M. Silica dust and sarcoidosis in Swedish construction workers. Occup Med Oxf Engl. 2019; 69: 482-486.

23 Ungprasert P, Crowson CS, Matteson EL. Sarcoidosis increases risk of hospitalized infection. A population-based study, 1976–2013. Ann Am Thorac Soc. 2017; 14: 676-681.

24 Kopiński P, Wypasek E, Senderek T, et al. Different expression of immune checkpoint markers on bronchoalveolar lavage $CD4^+$ cells: a comparison between hypersensitivity pneumonitis and sarcoidosis. Pol Arch Intern Med. 2021; 131: 16084.

25 Bogdan M, Nitsch-Osuch A, Kanecki K, et al. Sarcoidosis among hospitalized patients in Poland: a study based on a national hospital registry. Pol Arch Intern Med. 2019; 129: 580-585.

26 Kowalska M, Niewiadomska E, Zejda JE. Epidemiology of sarcoidosis recorded in 2006-2010 in the Silesian voivodeship on the basis of routine medical reporting. Ann Agric Environ Med. 2014; 21: 55-58.

27 Niewiadomska E, Kowalska M, Skrzypek M, et al. Incidence and economic burden of sarcoidosis in years 2011-2015 in Silesian voivodeship, Poland. Sarcoidosis Vasc Diffuse Lung Dis. 2020; 37: 43-52.

28 World Health Organization. WHO Coronavirus (COVID-19) Dashboard. https://covid19.who.int/. Accessed July 30, 2023.

29 Demographic data on the general Polish population. Condition and structure of the population. Statistics Poland. https://demografia.stat.gov.pl/BazaDemografia/CustomSelect.aspx. Accessed March 23, 2023.

30 Abramson JH. WINPEPI updated: computer programs for epidemiologists, and their teaching potential. Epidemiol Perspect Innov. 2011, 8: 1.

31 Lumley T, Diehr P, Emerson S, Chen L. The importance of the normality assumption in large public health data sets. Annu Rev Public Health. 2002; 23: 151-169.

32 López-Muñiz Ballesteros B, Noriega C, Lopez-de-Andres A, et al. Sex differences in temporal trends in hospitalizations and in-hospital mortality in patients with sarcoidosis in Spain from 2001 to 2020. J Clin Med. 2022; 11: 5367.

33 Morgenthau AS, Levin MA, Freeman R, et al. Moderate or severe impairment in pulmonary function is associated with mortality in sarcoidosis patients infected with SARS-CoV-2. Lung. 2020; 198: 771-775.

34 Brito-Zerón P, Gracia-Tello B, Robles A, et al. Characterization and outcomes of SARS-CoV-2 infection in patients with sarcoidosis. Viruses. 2021; 13: 1000.

35 Tripipitsiriwat A, Komoltri C, Ruangchira-Urai R, Ungprasert P. Clinical characteristics of sarcoidosis in Asian population: a 14-year single center retrospective cohort study from Thailand. Sarcoidosis Vasc Diffuse Lung Dis. 2020; 37: e2020011.

36 Jain R, Yadav D, Puranik N, et al. Sarcoidosis: causes, diagnosis, clinical features, and treatments. J Clin Med. 2020; 9: E1081.

37 Škopljanac I, Miše K, Šegrt I, Ilak D. Sarcoidosis in South Croatia, 30-year follow up. Eur Respir J. 2017; 50: PA2599.

38 Sève P, Pacheco Y, Durupt F, et al. Sarcoidosis: a clinical overview from symptoms to diagnosis. Cells. 2021; 10: 766.

39 Larsson J, Graff P, Bryngelsson IL, Vihlborg P. Sarcoidosis and increased risk of comorbidities and mortality in Sweden. Sarcoidosis Vasc Diffuse Lung Dis. 2020; 37: 104-135.

40 Rossides M, Kullberg S, Askling J, et al. Sarcoidosis mortality in Sweden: a population-based cohort study. Eur Respir J. 2018; 51: 1701815.

41 Desbois AC, Marques C, Lefèvre L, et al. Prevalence and clinical features of COVID-19 in a large cohort of 199 patients with sarcoidosis. Clin Exp Rheumatol. 2022; 40: 195-196.

42 Baughman RP, Lower EE, Buchanan M, et al. Risk and outcome of COVID-19 infection in sarcoidosis patients: results of a self-reporting questionnaire. Sarcoidosis Vasc Diffuse Lung Dis. 2020; 37: e2020009.

43 Hadi YB, Lakhani DA, Naqvi SFZ, et al. Outcomes of SARS-CoV-2 infection in patients with pulmonary sarcoidosis: a multicenter retrospective research network study. Respir Med. 2021; 187: 106538.

44 Baughman RP, Lower EE. COVID-19 infections in sarcoidosis: a prospective single center study of 886 sarcoidosis patients. Sarcoidosis Vasc Diffuse Lung Dis. 2021; 38: e2021029.