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Original Article

Epidemiological Study of Co-infection of Leprosy and COVID-19 in the State of Mato Grosso, 2020

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The COVID-19 pandemic has significantly impacted neglected diseases including leprosy leading to disruptions in global leprosy programs. Leprosy offers an intriguing model for investigating the impact of occurrence and severity of COVID-19. This study aimed to assess the risk of severe COVID-19 complications in patients with co-infection by COVID-19 and *M. leprae* through an exploratory spatio-temporal analysis of leprosy cases diagnosed in Mato Grosso. Brazil. Leprosy patient data was retrieved from the Notifiable Diseases Information System (SINAN) for 2018-2020. while COVID-19 patient data was obtained from the IndicaSUS system for 2020. The linkage of those databases yielded 861 true pairs. Leprosy cases showed a predominance of the population aged 15-59 (78.05%) and female (57.14%). Most cases were classified as multibacillary (94.43%). Among cases with co-infection. 28.46% had comorbidities. compared to 19.24% in the overall COVID-19 patient population. The fatality rate for co-infected patients was 4.88%. while the overall COVID-19 fatality rate was 2.32%. These findings indicate that leprosy can serve as a comorbidity factor for COVID-19 patients, elevating the risk of complications, including leprosy reactions. and potentially leading to fatal outcomes. Healthcare services for leprosy patients is crucial in the context of co-infection, such as COVID-19.

Keywords : Leprosy, COVID-19, Co-infection, Comorbidity, Brazil

Introduction

Leprosy, also known as Hansen's disease, is a chronic infectious disease of global importance. It is the second most common mycobacterial infection to affect humans, following tuberculosis, The etiological agent of leprosy is *Mycobacterium leprae*. Brazil is considered the country with the highest burden of the disease due to its high detection rate relative to the population size. However, it is estimated that underreporting of cases is a significant problem. The combat against leprosy's sequelae and transmission is only possible with a structured system of epidemiological surveillance and the establishment of early treatment (BRASIL 2016, 2019).

There were 208,619 new cases of leprosy reported worldwide in 2018. Among these, 30,957 occurred in the Americas region. with 28,660 (92.6% of the total in the Americas) reported in Brazil (BRASIL 2019). Out of the total number of newly diagnosed cases in the country, 1,705 (5.9%) occurred in children under 15 years of age. Regarding the Grade of Physical Disability

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(GPD), among the 24,780 (86.5%) evaluated at the time of diagnosis, 2,109 (8.5%) presented visible deformities (GPD2). Given this scenario, Brazil is classified as a country with a high burden of the disease, ranking second in the list of countries with the highest number of cases worldwide, only behind India (BRASIL 2016, 2019).

Leprosy is included in the international agenda. and among the globally committed objectives, the disease is addressed in Goal 3 of the Sustainable Development Goals (SDGs) of the United Nations (UN). This goal aims to promote well-being and a healthy life, with the target of combating epidemics of AIDS, tuberculosis, malaria, and other neglected communicable and tropical diseases by 2030. Additionally, the WHO has introduced the Global Leprosy Strategy 2016-2020, which aims to reduce the rate of new cases with Grade 2 physical disability to less than 1 case per 1,000,000 inhabitants and eliminate the number of Grade 2 cases in children (BRASIL 2016, 2017. 2019).

Leprosy is part of the National List of Compulsory Notification of Diseases in Brazil (Consolidation Ordinance MS/GM No. 4, of September 28. 2017). and therefore, it is mandatory for healthcare professionals to report cases of the condition in the Information System for Notifiable Diseases (Sinan). The analysis of the system data is crucial to identify different patterns of disease occurrence, areas of greater vulnerability, and weaknesses in the surveillance of this endemic disease in Brazil. The production and dissemination of information are important as they guide decision-making and provide a critical assessment of the system. aiming to identify inconsistencies that may affect the quality of information. The years 2020 and 2021 were critical for most neglected diseases. The COVID-19 pandemic disrupted the already fragile structure of global leprosy programs, affecting everything from the diagnostic chain to treatment with delays in medication distribution. This fact is evidenced by the reduction in leprosy detection rates during these years. In addition to the operational impact of the COVID-19 pandemic on leprosy treatment, clinical and immunological aspects are also important (BRASIL 2020).

One of the major problems related to SARS-CoV-2 infection is the erratic immune response that leads to severe pulmonary inflammation, pulmonary fibrosis, and death. Leprosy is also a disease highly dependent on the immune response of infected patients. It is believed that patients with the lepromatous pole, known for their cellular immune deficit, may be more susceptible to SARS-CoV-2 infection, but possibly not to severe pulmonary forms. Other inherent characteristics of leprosy management, such as treatment adherence and specific manifestations, also deserve to be studied, given the evident impact of the pandemic on society as a whole. It is believed that a better biological, clinical, and epidemiological understanding of co-infections is the most important pillar for excellence in healthcare (Baeck et al 2021, RECOVERY 2021).

Despite the urgency to implement public health actions to address COVID-19, the care for leprosy patients should not be interrupted, given the high likelihood of leprosy reactions occurring without continuous monitoring (BRASIL 2016, 2017, 2019, 2020). These reactions pose an increased risk of disability development, and their aggravation can lead to hospitalization, further burdening an already precarious and overwhelmed healthcare system due to the COVID-19 pandemic.

In addition to maintaining follow-up care for leprosy patients, it is also necessary to monitor individuals in contact with suspected cases. including them in the BCG vaccination campaign at healthcare facilities through a staggered approach to service. Although inconclusive, some studies indicate that BCG administration, besides being a stimulus for the immune response against leprosy, may also induce an immune response

against COVID-19, which could significantly reduce the severity and mortality caused by the novel coronavirus (Gong &Wu 2021).

Since the beginning of the COVID-19 pandemic, several possibilities regarding SARS-CoV-2 and *M. leprae* co-infection have been speculated, despite the scarcity of data (Antunes et al 2020, Santos Morais Junior et al 2021). Previous articles raised the possibility that co-infection would result in a higher frequency and intensity of leprosy reactions and that stimulation of the Th1 immune response, either after mycobacterial infection or after BCG vaccination, would act as a protective factor against COVID-19 (Madan et al 2020, Antunes et al 2020, Santos Morais Junior et al 2021).

COVID-19 results in an intense inflammatory response dependent on various mediators, including TNF and IL-6 (Coomes & Haghbayan 2020). The so-called cytokine storm syndrome can lead to severe pulmonary inflammation and fibrosis (Coperchini et al 2020). Many attempts to modulate this erratic immune response have been made with limited success (Stone et al 2020, RECOVERY 2021). Data from recent publications demonstrate that SARS-CoV-2 and *M. leprae* co-infection is followed by an intense IL-6 and IL-12 dependent response, but the clinical presentation of both diseases is not altered (Santos Morais Junior et al 2021).

Epidemiological and regional differences at the onset of the COVID-19 pandemic pointed towards a protective role of Th1 immune responses against this viral infection. Some scientists have raised the possibility of a protective effect of mycobacterial infection against COVID-19 (Madan et al 2020). Clofazimine and dapsone, medications used for leprosy treatment, have also demonstrated suppressive properties against SARS-CoV-2 in laboratory models (Farouk & and Salman 2020, Yuan et al 2021). The fact that leprosy is a mycobacterial infection highly dependent on immunological modulation makes endemic regions of leprosy an interesting model to test the effect of these variables on the occurrence and severity of COVID-19.

This study aimed to assess the risk for the development of severe complications of COVID-19 in patients with co-infection of COVID-19 and *M. leprae.*

Patients and Methods

Patients data

This study proposed an exploratory spatiotemporal analysis of leprosy cases diagnosed in the state of Mato Grosso, Brazil from 2018 to 2020. with co-infection by SARS-CoV-19.

The data of patients diagnosed with leprosy were obtained from the Notifiable Diseases Information System (SINAN), It included 14.793 reported and confirmed leprosy cases in the years 2018, 2019, and 2020 (SINAN 2016).

The data of patients with COVID-19 were obtained from IndicaSUS. which reported 207.106 cases in the year 2020, starting from the first reported case in the state in March 2020 (http://www.saude.mt.gov.br/painelcovidmt2/).

The present study was approved by the Research Ethics Committee of Hospital Júlio Muller. under the number CAAE 62873222.5.0000.8124. complying with Resolution No. 466/12 of the National Health Council and international ethical guidelines (Declaration of Helsinki).

Inclusion Criteria

Individuals diagnosed with leprosy reported in SINAN in the years 2018, 2019, and 2020, and COVID-19 cases reported in IndicaSUS from March to December 2020, all from the state of Mato Grosso.

Exclusion Criteria

Cases with missing variables that would allow the cross-referencing of information between the databases and leprosy cases with any type of misdiagnosis error.

Data Collection

In addition to frequency distribution. the following explanatory variables were selected: gender. age group (<15; 15-59; >60 years). operational classification of leprosy, clinical type of leprosy, detection method, and cardinal signs categorized as follows: cases without skin lesions and without neural involvement; cases with cutaneous lesions but without neural involvement; cases without skin lesions but with neural involvement; and cases with skin lesions and neural involvement.

Additional outcomes included the severity of COVID-19. Moderate and severe forms of COVID-19 were defined among cases with hospitalization, admitted patients, and/or with severity symptoms reported in the information system or those who died. Furthermore, the association of co-infection between SARS-CoV-2 and *M. leprae* with the occurrence of leprosy reactions and disabilities was analyzed.

Linkage Analysis

The method of linkage analysis was employed using the state leprosy (SINAN) database from 2018 to 2020 in the state of Mato Grosso, and the data of COVID-19 patients obtained from the IndicaSUS database from March to December 2020 in the state of Mato Grosso.

To accomplish this, criteria for identifying pairs was established through the Link Plus program, Link Plus is a probabilistic record linkage software developed by the Centers for Disease Control and Prevention (CDC). It is a free and independent application that, although originally designed for use with cancer registries, can be used with any type of fixed-width or delimited format data (https://www.cdc.gov/cancer/npcr/tools/registryplus/lp.htm).

Statistical Analysis

To evaluate the statistical data, selected characteristics of COVID-19 or leprosy patients were compared to the COVID-19 and leprosy linkage population. Percentage values were compared using the Student's t-test, employing the STATA software. P-values < 0.05 were considered statistically significant.

Results

Epidemiological Analysis of Reported Leprosy Patients

In the present study, the average population of the state exhibiting clinical manifestations of leprosy between 2018 and 2020 was evaluated. Among these patients. 49.81% were males. The majority of patients had brown skin color (55.22%). In terms of age range, there was a predominance of individuals between 15 and 59 years old (75.04%). Cases involving individuals under the age of 15 accounted for 3.69% of the total cases (Table 1).

Based on the operational classification. the majority of the investigated cases were multibacillary (94.99%), and according to the clinical form, the majority presented with the dimorphic form (79.70%). Assessment of skin lesions showed that most patients had skin lesions (81.12%). Nerve involvement indicated that the majority of the population had more than 2 affected nerves (68.90%). Regarding leprosy reactions, 7.10% exhibited type 1 reaction, and 1.84% exhibited type 2 reaction during the evaluated period (Table 1).

Epidemiological analysis of patients reported with COVID-19

When evaluating the population of the state that presented clinical manifestations of COVID-19 in 2020, it was noted that 47.20% of the patients were male. The majority of patients had a mixed race (52.68%). The age range was analyzed, as well as in the leprosy population. considering the importance of assessing cases under and over 15 years old, as it is an important indicator of this disease. Therefore, for COVID-19, the same age range was maintained for analysis. and the population aged more than 60 years

Table 1 : Demographic characteristics of reported leprosy cases in the state of Mato Grosso, Brazil, from 2018 to 2020.

Characteristics		2018		2019		2020		Total	
		n	%	n	%	n	%	n	%
Age	< 15 years	195	3.42	220	3.93	131	3.76	546	3.69
	15 to 59	4.279	74.99	4.208	75.13	2.6|14	74.99	11.101	75.04
	> = 60	1.211	21.22	1.173	20.94	741	21.26	3.125	21.12
	No data	21	0.37	0	0.00	0	0.00	21	0.14
Gender	Feminine	2.912	51.03	2.846	50.81	1.665	47.76	7.423	50.18
	Masculine	2.793	48.95	2.755	49.19	1.821	52.24	7.369	49.81
	No data	1	0.02	0	0.00	0	0.00	1	0.01
Skin colour	Caucasian	1.797	31.49	1.816	32.42	1.114	31.96	4.727	31.95
	Black	600	10.52	549	9.80	357	10.24	1.506	10.18
	Yellow	39	0.68	49	0.87	23	0.66	111	0.75
	Brown	3.156	55.31	3.077	54.94	1.936	55.54	8.169	55.22
	Indian	17	0.30	27	0.48	9	0.26	53	0.36
	No data	97	1.70	73	1.28	37	1.35	227	1.54
Operational classification	Paucibacillary	334	5.85	278	4.96	127	3.64	739	5.00
	Multibacillary	5,371	94.13	5,322	95.02	3,359	96.36	14,052	94.99
	No data	1	0.02	1	0.02	0	0.00	2	0.01
Clinical form	Indeterminate	274	4.80	212	3.79	123	3.53	609	4.12
	Tuberculoid	199	3.49	181	3.23	116	3.33	496	3.35
	Borderline	4,529	79.37	4,524	80.77	2,737	78.51	11,790	79.70
	Lepromatous	363	6.36	393	7.02	286	8.20	1042	7.04
	No data	341	5.98	291	5.20	224	6.43	856	5.79
Skin lesion	0	605	10.60	656	11.71	450	12.91	1711	11.57
	< = 5 lesions	4,752	83.28	4,457	79.58	2,791	80.06	12,000	81.12
	> 5	2,475	40.02	2,240	36.22	1,470	23.77	6,185	51.54
	No data	349	6.12	488	8.71	245	7.03	1,082	7.31
Affected nerves	0	920	16.12	884	15.78	575	16.49	2,379	16.08
	1	586	10.27	502	8.96	330	9.47	1,418	9.59
	> 1	3,892	68.21	3,895	69.54	2,406	69.02	10,193	68.90
	No data	308	5.40	320	5.71	175	5.02	803	5.43
Leprosy reaction	Type 1	425	7.45	399	7.12	226	6.48	1,050	7.10
	Type 2	103	1.81	112	2.00	57	1.64	272	1.84
	Type 1 and 2	31	0.54	34	0.61	24	0.69	89	0.60
	No reaction	4,229	74.11	3,734	66.67	2,110	60.53	10,073	68.09
	No data	918	16.09	1,322	23.60	1,069	30.67	3,309	22.37

Source: Sinan Leprosy Database-MT. referring to the years 2018 to 2020, made available in November 2022.

predominantly manifested the disease (48.24%), followed by the 15 to 59 years (32.15%), and children under 15 years old (19.61%). Regarding the presence of comorbidities, only 19.24% of patients presented clinical manifestations. As for the clinical outcome. 2.32% of patients died (Table 2).

Epidemiological analysis between the databases of patients reported with leprosy and COVID-19.

Regarding the linkage performed between the Sinan leprosy database and the IndicaSUS COVID-19 database, 861 true pairs were obtained. Considering the characteristics of leprosy, there was a predominance of the population between 15 and 59 years old (78.05%), female (57.14%), and of mixed race (51.57%). The majority of cases presented the multibacillary operational classification (94.43%) and the dimorphic clinical form (81.65%). Regarding the most relevant clinical characteristics, it was identified that 50.92% of the cases presented 5 or more skin lesions, 67.81% had 2 or more affected nerves, 5.69% of the cases manifested type 1 leprosy reaction, and 1.74% manifested type 2 leprosy reaction (Table 3).

Regarding cases of co-infection with COVID-19 and *M. leprae*, in relation to the clinical characteristics of leprosy, it was identified that 28.46% of the cases presented comorbidities. while among the total number of patients with COVID-19, 19.24% had comorbidities. Among the cases with co-infection, 4.88% of the patients died, while among the total number of patients with COVID-19, 2.32% had this outcome. As for other characteristics. there was a similarity in the results. For example, the majority were female

Table 2 : Demographic and clinical characteristics of notified COVID-19 cases in the state of Mato Grosso, Brazil, 2020.

Characteristics		N	%
Age	< 15 years	10,415	19.61
	15 to 59	17,073	32.15
	> = 60	25,618	48.24
Gender	Feminine	109,344	52.8
	Masculine	97,762	47.2
Skin colour	Caucasian	57,876	27.95
	Black	8,928	4.31
	Yellow	5,185	2.50
	Brown	109,109	52.68
	Indian	2,688	1.30
	No data	23,320	11.26
Comorbidity	Yes	39,849	19.24
	No	167,257	80.76
Case outcome	Recovery	202,204	97.63
	Death by COVID	4,809	2.32
	Death by other causes	28	0.01

Source: IndicaSUS COVID-19-MT database, referring to the year 2020, made available in November 2022.

Table 3 : Demographic and clinical characteristics of leprosy for cases of COVID-19 and *M leprae* co-infection reported in the state of Mato Grosso, Brazil, from 2018 to 2020.

Characteristic		Total patients with co-infection		Total leprosy patients		P value
		n	%	N	%	
Age	< 15 years	13	1.51	546	3.69	0.0008
	15 to 59	672	78.05	11,101	75.04	
	> = 60	176	20.44	3,125	21.12	
	No data	0	0	21	0.14	
Gender	Feminine	492	57.14	7,423	50.18	0.3210
	Masculine	369	42.86	7,369	49.81	
	No data	0	0	1	0.01	
Skin colour	Skin colour	315	36.59	4,727	31.95	0.9656
	Black	83	9.64	1,506	10.18	
	Yellow	5	0.58	111	0.75	
	Brown	444	51.57	8,169	55.22	
	Indian	2	0.23	53	0.36	
		12	1.39	227	1.54	
Operational classification	Paucibacillary	48	5.57	739	5	0.9999
	Multibacillary	813	94.43	14,052	94.99	
	No data	0	0	2	0.01	
Clinical form	Indeterminate	29	3.37	609	4.12	0.8863
	Tuberculoid	40	4.65	496	3.35	
	Borderline	703	81.65	11,790	79.7	
	Lepromatous	49	5.69	1,042	7.04	
	No data	40	4.65	856	5.79	
Skin lesion	No	98	11.38	1,711	11.57	0.9968
	< = 5 lesions	705	81.88	12,000	81.12	
	> 5	359	50.92	6,185	51.54	
	No data	58	6.74	1,082	7.31	
Affected nerves	0	136	15.8	2,379	16.08	0.9709
	1	98	11.38	1,418	9.59	
	>1	583	67.71	10,193	68.9	
	No data	44	5.11	803	5.43	
Leprosy reaction	Type 1	49	5.69	1,050	7.1	0.5810
	Type 2	15	1.74	272	1.84	
	Type 1 and 2	4	0.46	89	0.6	
	No reaction	610	70.85	10,073	68.09	
	No data	183	21.25	3,309	22.37	

Source: Sinan Leprosy Database-MT. referring to the years 2018 to 2020. made available in November 2022.

Table 4 : Demographic and clinical characteristics of cases with co-infection of COVID-19 and *M. leprae,* reported in the state of Mato Grosso, Brazil, 2020.

Characteristic		Total of patients with co-infection		Total of COVID patients		P Value
		N	%	n	%	
Comorbidity	Yes	245	28.46	39,849	19.24	0.05
	No	616	71.54	167,257	80.76	
	Recovered	818	95.01	202,204	97.66	
Case outcome	Death	42	4.88	4,809	2.32	0.1242
	Other	1	0.12	28	0.01	
Gender	Feminine	493	57.26	109,344	52.8	0.5697
	Masculine	368	42.74	97,762	47.2	
Age	< 15 years	8	0.93	10,415	5.03	0.0291
	15 to 59	644	74.8	171,073	82.6	
	> = 60	209	24.27	25,618	12.37	
Skin colour	Caucasian	241	27.99	57,876	27.95	0.8830
	Black	69	8.01	8,928	4.31	
	AMARELA	20	2.32	5,185	2.50	
	Yellow	471	54.70	109,109	52.68	
	Indian	1	0.12	2,688	1.30	
	No data	59	6.85	23,310	11.23	

Source: IndicaSUS COVID-19-MT database. referring to the year 2020, made available in November 2022.

(57.26% and 52.8%), with the predominant age group between 15 and 59 years (74.80% and 82.6%), and the predominant skin color was brown (54.70% and 52.68%) (respectively, co-infection COVID-19 and *M. leprae* and total COVID-19) (Table 4).

Among cases with COVID-19 and *M leprae* co-infection and a fatal outcome, it was observed that the cases were predominantly multibacillary leprosy (92.86%), with a dimorphic clinical form (80.95%), presenting skin lesions (83.33%), and having 2 or more affected nerves (69.05%). Regarding cases of physical disability due to leprosy, 35.71% of the cases had grade I physical disability, and 9.52% had grade II at the time of disease diagnosis. Regarding leprosy reactions, 4.5% presented with type 1 reaction, and 4.5% presented with type 2 reaction (Table 5).

The main comorbidities listed in the database were hypertension, diabetes, obesity, and chronic kidney diseases. Among the cases that presented comorbidity and co-infection with COVID-19 and *M leprae* (n = 245). It was observed that 96.73% of the cases had multibacillary leprosy, 86.92% had the dimorphic clinical form. and 65.31% had two or more affected nerves. Out of the total cases that presented co-infection and the outcome of death (n=42), 80.95% had at least one of the listed comorbidities (Table 6).

Table 5 : Clinical characteristics of leprosy among cases that presented co-infection and fatal outcome for COVID-19, reported in the state of Mato Grosso, Brazil, in 2020.

Characteristics		n	%	P value
Operational classification	Paucibacillary	3	7.14	0.7742
	Multibacillary	39	92.86	
	Indeterminate	1	2.38	
Clinical form	Tuberculoid	3	7.14	0.7368
	Borderline	34	80.95	
	Lepromatous	3	7.14	
	Not classified	1	2.38	
Skin lesions	No	3	7.14	0.3481
	Yes	35	83.33	
	No data	4	9.52	
Affected nerves	0	5	11.90	0.7308
	1	4	9.52	
	>1	29	69.05	
GIF evaluation	No data	4	9.52	0.7222
	0 Grade	16	38.10	
	Grade I	15	35.71	
	Grade II	4	9.52	
	No data	7	16.66	
Leprosy reaction	Type 1	2	4.76	0.2226
	Type 2	2	4.76	
	No reaction	19	45.24	
	No data	19	45.24	

Source: Sinan Hanseníase-MT database, referring to the years 2018 to 2020, made available in November 2022.

Table 6 : Clinical characteristics of leprosy cases that presented comorbidities for COVID-19 in patients with co-infection of COVID-19 and M leprae, reported in the state of Mato Grosso, Brazil, from 2018 to 2020.

Characteristics		n	%	P value
Comorbidity	Multibacillary	237	96.73	0.3062
	Borderline	206	94.93	
	Lepromatous	11	5.07	0.7354
	Death	34	13.88	0.030
Affected nerves	0	44	17.96	0.8994
	1	23	9.39	
	>1	160	65.31	
	No data	18	7.35	

Source: Sinan leprosy database-MT from 2018 to 2020 and IndicaSUS COVID-19-MT in 2020, made available in November 2022.

Discussion

This study evaluates patients who presented co-infection with COVID-19 and *M. leprae* in the year 2020, aiming to identify whether leprosy could be a comorbidity for COVID-19. The data presented in this study showed that 14, 793 patients from Mato Grosso were diagnosed with leprosy between the years 2018 and 2020, and 207,106 were diagnosed with COVID-19 in 2020. Evaluating the data on co-infection, 5.8% of leprosy patients presented co-infection with COVID-19 and *M. leprae*. These findings are consistent with Repsold and collaborators (2022), who evaluated a population of 1,377 leprosy patients and found that 5.1% had co-infection with COVID-19.

Analyzing the clinical data of leprosy patients and patients with co-infection of COVID-19 and *M. leprae*, it is observed that the number of multibacillary patients was similar (approximately 95%), with a predominance of the dimorphic clinical pattern (approximately 95%). Similarly, comparable data (95% multibacillary and 70% dimorphic) was reported by Repsold et al (2022). However, the population of lepromatous patients was higher among coinfected patients (7.4%) compared to leprosy patients (5%). The data presented by Repsold and collaborators (2022) indicate a higher percentage, approximately 20%, which may be related to care provided at a leprosy specialty center. This increasing trend in the lepromatous leprosy population observed in the data from Mato Grosso may be indicative of a more exacerbated inflammatory process for patients with co-infection. Morais Jr and collaborators (Santos Morais Junior et al 2021) observed that patients with COVID-19 and *M. leprae* co-infection had increased levels of IL-6 and IL-12, which could induce a more exacerbated inflammatory process.

Regarding leprosy reactions, patients with co-infection exhibited type 1 and type 2 reactions with a frequency similar to that of patients with leprosy in general. The data presented by Repsold and collaborators (2022) indicate a percentage of 31.5% of reactive patients, which may be related to care provided at a leprosy specialty center. Patients with type 1 reaction in leprosy present a greater signaling cascade and release of IL-17, while patients with type 2 reaction exhibit an intense antibody response and an ineffective response of effector T cells. Aponso et al (2022) reported a case of a patient with co-infection of COVID-19 and *M. leprae* in an exacerbated type 2 reaction, Schmitz & dos Santos (2021) also highlight the complexity of type 2 reaction in patients coinfected with COVID-19 and *M. leprae*, highlighting the role of neutrophils in both diseases. Other authors also discuss the importance of monitoring patients with leprosy reactions, especially during episodes of COVID-19 (Bhandari ett al 2022, Saraswat et al 2022). Despite the data from Mato Grosso not showing changes in the total number of patients with reactive states, the literature emphasizes the importance of monitoring these patients and the potential risk of exacerbating their clinical condition.

Considering the number of affected nerves, patients with co-infection of COVID-19 and *M. leprae* did not have alterations in the percentage of patients with two or more affected nerves. Patients who died from COVID-19 had a higher frequency of having 2 or more affected nerves (69%), but this difference was not significant. De Oliveira and collaborators (de Oliveira et al 2022) describe that COVID-19 and leprosy have a very important potential for neuroinflammation, particularly through the activation of tryptophan catabolism via the kinurenine signaling pathway. These authors discuss that the co-infection of these diseases may potentiate neural damage in these patients in short or long term, leading to the development of relevant sequelae. This data is interesting and could be an additional factor

to observe during the 5-year follow-up period of leprosy patients post-cure.

Regarding comorbidities, patients with co-infection of COVID-19 and *M. leprae* represented a higher-risk population, showing a higher percentage of comorbidities. Similar findings were also observed (Santos Morais Junior et al 2021, Repsold et al 2022).

Finally, regarding the outcome of patients with COVID-19 and leprosy, it was observed that 4.88% of these patients died, while in the general population with COVID-19, the mortality rate was 2.32%. Particularly, among the patients who died from COVID-19 and had leprosy, 80.9% had some type of comorbidity. Santos Morais Junior et al (2021) observed a high mortality rate among patients with COVID-19 and lepromatous leprosy in Aracaju (SE), Brazil. On the other hand, Repsold et al (2022) did not observe any deaths in the studied population of patients with COVID-19 and leprosy. These discordant results indicate that risk of death may not have direct linkage with leprosy but may be influenced by other co-morbidities.

In conclusion, it can be observed that leprosy can be a comorbidity factor for patients with COVID-19, increasing the chances of these patients developing complications in leprosy reactions or experiencing complications that could lead to death. Further studies should be conducted to validate this information. The healthcare attention for patients with leprosy should be expanded due to the long incubation and treatment periods of the disease, which can make these patients more susceptible to health risks, particularly under conditions of co-infections such as COVID-19.

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