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ORIGINAL RESEARCH

Severe COVID-19 in Patients with Immune-Mediated Rheumatic Disorders: A Case-Control Study

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Purpose: To assess the impact of severe COVID-19 in patients with immune-mediated rheumatic diseases (im-RD) and compare their morbidity, mortality, hospitalization issues, post-COVID-19 sequelae, and the financial burden of COVID-19 with those of patients without im-RD.

Patients and Methods: We conducted a retrospective case–control study that included 132 consecutive patients with im-RD who visited the Rheumatology Department of a public hospital in the Emirate of Dubai and were hospitalized for COVID-19 infection between March 1st, 2020, and December 31st, 2021, (cases). We included 264 and 132 age- and sex-matched patients without im-RD in matched-I and matched-II control groups, respectively. The median age of patients and controls was 48.5 years, and 74.2% were female. Patients with im-RD were paired with an unforced nearest neighbor match using a caliper width of 0.2 standard deviations of the matched-II control group's propensity score. We compared the relative risk of death, disease progress, use of medical resources, and financial impact of COVID-19 between patients and controls.

Results: Patients with im-RD had higher mortality rates than the matched-I (odds ratio, OR: 11.2, $p < 0.000$) and matched-II (OR: 16.8, $p < 0.006$) control groups. The overall complication rate was also significantly higher in patients with im-RD than in matched-I (OR = 2.9, $p < 0.000$) and matched-II (OR = 2.8, $P < 0.0001$) control groups. Lastly, patients with im-RD required more frequent visits to the clinic, a longer recovery time following hospital discharge, and increased healthcare costs compared to the control groups.

Conclusion: COVID-19 infection in patients with im-RD is associated with increased morbidity and mortality, exerting a significant burden on the healthcare system.

Plain Language Summary: We performed a retrospective case–control study to evaluate the effect of severe COVID-19 in patients with immune-mediated rheumatic disease (im-RD). In this study, we compared the morbidity, mortality, facility-level factors, post-COVID sequelae, and financial burden of 132 cases of im-RD with two control groups, matched by age and sex, who did not have im-RD. Our key findings are that patients with im-RD:

- Exhibited a considerably greater death rate than controls.
- Have higher disease complication rates, including pneumonia, secondary infections, and immunological thrombocytopenia.
- Experience longer hospital stays and more ICU admissions.
- Have higher use of healthcare resources after discharge.
- Have higher direct and indirect expenditures.

The implications of our study are as follows:

- Patients with im-RD require more aggressive COVID-19 treatment strategies.
- Tailored protocols and closer monitoring is needed for this high-risk group.
- Healthcare systems should allocate more resources for im-RD patients with COVID-19.
- Prioritization of vaccination and booster programs for im-RD patients is required.
- Further research is required on optimizing COVID-19 management in this population.

In summary, this study highlights the significantly higher clinical and financial burden of severe COVID-19 in patients with im-RD, emphasizing the need for specialized care approaches and resource allocation for this vulnerable group.

Received: 6 December 2024
Accepted: 1 April 2025
Published: 5 April 2025

Keywords: rheumatic diseases, COVID-19, mortality, morbidity, financial burden

Introduction

The COVID-19 pandemic severely impacted people worldwide, resulting in significant socioeconomic burdens and exceptional challenges to medical care, particularly for those with chronic diseases. The pandemic significantly disrupted the management of immune-mediated rheumatic diseases (im-RD), affecting healthcare delivery, medication accessibility, and treatment adherence.[1] Numerous patients had to postpone or cancel their medical appointments, which presumably worsened their conditions.[2] Furthermore, rheumatologists had to modify standard treatments as patients were concerned about increased susceptibility to COVID-19, which potentially impacted their disease activity.[3] During this phase, telemedicine became the standard practice, which had its merits and demerits.[1]

Several comorbidities during COVID-19 are associated with increased disease severity and mortality rates in the general population. Large registries and systematic reviews have shown that obesity (particularly in young adults [18–39 years old]), cardiovascular diseases, diabetes mellitus, chronic respiratory illnesses, and hypertension increase the risk of developing severe COVID-19 and mortality in the general population.[4,5] Furthermore, there is a positive correlation between a patient's number of comorbidities and the risk of death and intensive care unit (ICU) admission.[4] COVID-19 infection in patients with im-RD is influenced by various disease-specific and general risk factors, increasing their likelihood of experiencing severe COVID-19 compared with that of the general population. There are several reports of patients with im-RD having a higher risk of acquiring severe acute respiratory coronavirus-2 (SARS-CoV2) infection or developing severe COVID-19 than that by the general population.[2,6] In addition, inflammatory dysregulation in patients with im-RD could aggravate SARS-CoV-2 disease outcomes.[2,6,7] In fact, in patients with COVID-19, inflammation and immune-mediated hyperactivation may lead to poor outcomes.[8] Disease activity levels in im-RDs are crucial for disease management, with higher disease activity being correlated with increased vulnerability to COVID-19 infection.[9] Additionally, treatment with steroids and immunosuppressive medications may boost COVID-19 risk.[3] Pre-existing comorbidities prevalent among patients with im-RDs, such as cardiovascular diseases and diabetes, along with factors that increase COVID-19 severity in the general population, such as advanced age, male sex, and obesity, increase the risk of severe infection among patients with im-RD, resulting in a complex risk profile.[2,3,8]

Studies have shown a significant association between im-RD and rates of hospitalization, ICU admission, mechanical ventilation, mortality, and other postinfection complications compared with those in patients without im-RD.[9–15] However, several studies found no association after thoroughly controlling for possible confounders, such as comorbidities and body mass index (BMI) at baseline.[14–20] A study found ethnicity as a potentially significant factor influencing COVID-19 severity and clinical outcomes in the general population, which may explain some of the differences in clinical outcomes observed between studies.[21]

So far, only a few studies have reported on COVID-19-related mortality rates in patients with im-RDs in the Middle East;[13,22] however, the data are from an observational study and a cross-sectional rheumatological survey. In this context, the current study compared the mortality rate of patients with im-RD who acquired severe COVID-19 infection (as defined by the UAE National Guidelines for Clinical Management and Treatment of COVID-19)[23] and required hospitalization with a control group (patients without im-RD) and examined the incidence of post-COVID-19 complications and the associated financial costs in both groups.

Materials and Methods

Study Design

This retrospective case–control study analyzed the electronic medical records (EMR) of all patients with primary diagnosis of im-RD who were admitted to Dubai Health's four major hospitals in Dubai, United Arab Emirates, because of COVID-19 infection between March 1, 2020, and December 3, 2021. Age- and sex-matched patients without im-RD who were hospitalized for COVID-19 management during the same period were used as controls.

Patient Selection

We screened all individuals diagnosed with im-RD before March 1, 2020, who were being followed up at the rheumatology department in Dubai Hospital and tested positive on the COVID-19 polymerase chain reaction (PCR) test between March 2020 and December 2021. According to the classification criteria provided by the American College of Rheumatology, the European League Against Rheumatism, or the Assessment of SpondyloArthritis International Society, adult patients (≥18 years) diagnosed with one of the following im-RD were eligible: rheumatoid arthritis, systemic lupus erythematosus, Sjögren's disease, diffuse systemic scleroderma, limited scleroderma, mixed connective tissue disease, dermatomyositis, polymyositis, radiographic and nonradiographic axial spondyloarthritis, psoriatic arthritis, enteropathy arthritis, undifferentiated seronegative arthritis, reactive arthritis (eg, Reiter's syndrome), adult-onset juvenile arthritis, and systemic vasculitides. Furthermore, patients who had at least two appointments with the clinic (a telemedicine consultation or an office visit) during the pandemic were screened. We included patients hospitalized for COVID-19 during this period who had provided consent for reviewing their medical records by signing the hospital general consent form. Those under 18 years of age, those not hospitalized due to COVID-19, or those who were lost to follow-up 12 months before March 1, 2020, were excluded.

In total, 1243 patients had an im-RD confirmed diagnosis and acquired COVID-19 during the pandemic; of these, only 132 patients met the inclusion and exclusion criteria.

Recruiting Matched Controls

Age- and sex-matched patients who were hospitalized with COVID-19 during the same timeframe and were ruled out for im-RD by the rheumatology clinic, Dubai Health, were recruited as controls. These participants were diagnosed with non-im-RD diseases, such as osteoarthritis, chronic noninflammatory back pain, crystal-induced arthropathy, primary fibromyalgia, widespread pain syndrome, nonspecific arthralgia, and bursitis/tendinitis. Eligible subjects had no history of im-RD or current/past use of disease-modifying antirheumatic drugs and provided consent for reviewing their EMR by signing the hospital's general consent form. In total, 6092 patients were identified, of whom only 635 were hospitalized. Using the *RAND* function in Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) for Windows 2019, we generated a random number to identify age and sex matches among patients with im-RD; each im-RD case was matched randomly with two controls of similar age and sex. The process of recruitment and matching is outlined in Figure 1.

Data Collection

All pertinent information for cases and controls, encompassing demographics, comorbidities at the time of COVID-19 infection, hospitalization-related data, and clinical outcomes of COVID-19 management were retrieved from the participant's EMR.

Demographic Information

1. Age at the time of testing positive for COVID-19.
2. Sex.
3. Ethnicity: Classified based on country of origin outlined in Section 1.0 Ethnicity in the Supplementary Material.
4. Work status: We reviewed patients' employment situation at the time of COVID-19 infection and classified them into one of six distinct categories: unemployed, student, homemaker, full-time employed, part-time employed, or retired.
5. Smoking status: Smoker (current or past smoker) or nonsmoker (never smoked).
6. BMI: <18.5 kg/m^2, underweight; 18.5 to <25 kg/m^2, healthy; 25 to <30 kg/m^2, overweight; >30 kg/m^2, obese.

Comorbidities at the Time of COVID-19

The comorbidities at the time of COVID-19 infection, as retrieved from medical records, included osteoporosis, hyperlipidemia, diabetes mellitus, arterial hypertension, cardiovascular disease, asthma/chronic obstructive pulmonary disease (COPD) or interstitial lung disease, chronic kidney disease, primary site malignancy, depression, active or latent

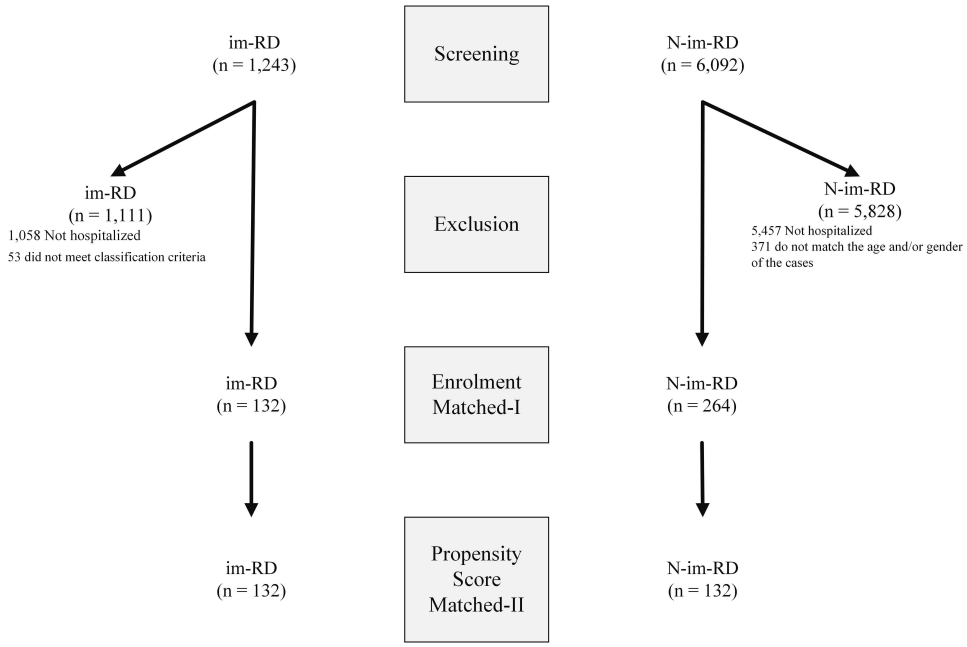

Figure 1 Strategies for patient recruitment and matching.

tuberculosis, history of herpes zoster, and clinical/serological diagnosis of hepatitis B or C. The definition of comorbidities at the time of COVID-19 infection is described in detail in Section 2.0 Comorbidities in the Supplementary Material.

Medication History

EMRs were checked to ascertain if patients were taking any of the following medications at the time of COVID-19 infection or in the past year:

- Prednisolone or its equivalent for >1 month: Average dose categorized as <5 mg/day, 5–10 mg/day, 11–15 mg/day, 16–20 mg/day, or >20 mg/day.
- Conventional disease-modifying antirheumatic drugs (c-DMARDs): Cyclosporine, sulfasalazine hydroxychloroquine, methotrexate, leflunomide, azathioprine, cyclophosphamide, and mycophenolate mofetil.
- Biological DMARDs (b-DMARDs): Tumor Necrosis Factor (TNF)-alpha inhibitors (Anti-TNF) – etanercept, infliximab, adalimumab, certolizumab pegol, and golimumab; Interleukin-17 (IL-17) inhibitor – secukinumab, ixekizumab; IL-23 inhibitor – guselkumab; other bDMARDs – rituximab, tocilizumab, abatacept, and belimumab.
- Targeted synthetic DMARDs (ts-DMARDs): Tofacitinib, baricitinib, and upadacitinib.

COVID-19-Related Data

Date of first COVID-19 PCR positive results, vaccination status at the time of infection, date of vaccination and doses, and vaccine type.

Hospital Admission

Date of admission and discharge were recorded along with the results of the following laboratory tests on admission: serum ferritin, leukocyte count, neutrophil-to-lymphocyte ratio, platelet count, D-dimers, C-reactive protein, procalcitonin, lactate dehydrogenase, and serum albumin.

We also documented the level of care provided during hospitalization and duration of stay in the following subcategories: critical care, high dependency, regular dependency, and low dependency. We calculated the expected length of stay for the diagnosis-related group (DRG) upon discharge—this categorization required a primary diagnosis of COVID-19 and

a secondary diagnosis from specified subgroups: (a) absence of comorbidities or significant complications, (b) specific secondary conditions that may be classified as comorbidities or complications (CCs), (c) secondary conditions assessed to determine whether they met the criteria for major comorbidities or complications. The expected average length of stay and associated billing for each DRG code and bed definition are detailed in Tables S 4.1, S 4.2, and S 4.3 in section 4.1 Disease-Related Group and 4.2 in the Supplementary Material. We assessed the patient's overall length of stay, including additional hospital days exceeding the expected length of stay, and the total cost of hospital stay.

Next, we retrieved data regarding medications used to manage COVID-19 during hospitalization: hydroxychloroquine, bamlanivimab, hydrocortisone/prednisolone, dexamethasone, favipiravir, remdesivir, redeliver, nebulized interferon alpha or interferon beta, peginterferon, camostat, tocilizumab, sarilumab, and lopinavir/ritonavir.

Lastly, data regarding the use of oxygen therapy during hospitalization were collected. These included oxygen saturation upon admission, employment of standard oxygen masks, administration of high-flow oxygen, noninvasive ventilation methods, intubation, extracorporeal membrane oxygenation, and whether the patient underwent an elective tracheostomy due to challenges of extubation. We also obtained information on additional treatments such as continuous renal replacement therapy (CRRT), peritoneal dialysis, and hemodialysis.

We also noted the occurrence of any of the following events during admission for COVID-19:

- Thrombotic events: Venous thromboembolism or arterial thrombosis
- Cardiovascular complications: Myocardial infarction, acute heart failure, dysrhythmias, or myocarditis
- Pneumonia: Clinical features of pneumonia confirmed by the presence of consolidation on a chest X-ray (posteroanterior view)
- Acute respiratory failure: Characterized by hypoxia, marked by an arterial partial pressure of oxygen (PaO_2) of <60 mmHg, with or without hypercapnia
- Acute respiratory distress syndrome: Classified as per the Berlin definition[24]
- Acute kidney injury[25]
- Acute liver injury: Defined as sudden damage to hepatocytes and is characterized by elevated liver enzyme levels in patients without pre-existing liver disease. This condition may lead to impaired synthetic function of the liver (INR > 1.5) and deterioration of mental status in the severe cases.
- Secondary infection: Another infection contracted concomitant with the COVID-19 infection
- Septic shock[26]
- Fungal infection

Neurological complications: We retrieved information on the occurrence of impaired consciousness, seizures, acute cerebrovascular disease, and ataxia during admission.

- Disseminated intravascular coagulation[27]
- Cytokine release syndrome[28]
- Acute pancreatitis
- Immune thrombocytopenia
- Adverse pregnancy outcomes: We reviewed the EMR data for the incidence of abortion, preterm birth, preeclampsia, and stillbirth in female patients who were pregnant within 9 months of COVID-19 infection.

Given the challenges of defining death due to COVID-19.[29] Death in patients with COVID-19 can be classified as the cause of death, irrespective of the contribution of pre-existing diseases to death. Furthermore, it can be recorded as a cause of death in probable or suspected cases without testing. This approach prioritizes public health over medical evaluations. Identifying COVID-19 as the underlying cause involves both factual (medical conditions) and nonfactual (prevention importance) considerations. Epidemiology, public health, health communication, and policy are affected by this categorization challenge. The key problem is reconciling accurate medical evaluation with public health considerations, which may lead to a less exact but prevention-focused COVID-19 death classification. We examined the patient's

EMR to determine the number of deaths and the cause of death during admission. We also collected data for the number of post-COVID-19 home visits, post-COVID-19 clinic visits, specialty clinic visits, the duration of nursing care needed postdischarge, the duration and frequency of home physiotherapy, and readmission within a month of the discharge date. Additionally, cases and controls were followed throughout the study period, and for 3 months beyond the study period, to capture occurrences of death and complications.

Total COVID-19-Related Cost

The overall cost of COVID-19 infection included direct and indirect costs:

1. Direct costs: Cost of hospital stay as estimated by DRG charges, additional days beyond the expected DRG stay, and additional procedures performed during hospitalization not covered by DRG.
2. Indirect expenditures: Include postdischarge and follow-up care costs and lost productivity. After discharge, patients require clinic visits, home visits, nursing care, and postdischarge care. Additionally, during an infection, the patient is unable to return to work for prolonged periods which includes hospitalization, recovery until the patient can return to work, and quarantine. We used Dubai's 2022 yearly employee compensation data to analyze productivity loss due to patient's incapacity to work (average annual compensation: AED 190,337).[30]

im-RD Specific Data

Data regarding the im-RD diagnosis, disease duration at the time of COVID-19 infection, and the average Modified Disease Activity Scores including 28 joints (DAS 28) to assess disease activity in patients with rheumatoid arthritis,[31] Ankylosing Spondylitis Disease Activity Score (ASDAS) to assess activity in patients with axial spondyloarthritis,[32] and Systemic Lupus Erythematosus Disease Activity Index (SLEDAI-2K) to assess disease activity in patients with systemic lupus erythematosus[33] in the 12 months preceding COVID-19 infection and in the first 6 months following COVID-19 infection, were collected. A summary of the im-RD diagnosis and management data is detailed in Supplementary Table 5.1

Statistical Analysis

Categorical data were presented as frequency and percentages and continuous variables were described using median and interquartile range (IQR). Categorical variables were compared using chi-squared or Fisher's exact tests, and continuous variables were compared using ANOVA to determine whether there were any statistically significant differences between the means of the three groups (cases and the two control groups). Statistical significance was determined using a p-value of <0.05 (two-tailed). We used two matched control groups to compare the clinical outcomes of the im-RD and control groups—matched-I and matched-II groups; all patients with im-RD were compared to age and sex-matched controls (1 case to 2 controls). We used propensity score matching to address potential confounding factors and balance the characteristics between cases and controls. The propensity scores were calculated using logistic regression, including relevant covariates that have been associated with poor COVID-19 outcomes, such as age, sex, smoking status, BMI, cardiovascular comorbidities, risk factors for cardiovascular disease, pulmonary comorbidities, stage of chronic kidney disease before COVID-19 infection, and infectious comorbidities. We performed a 1:1 nearest neighbor unforced matching using a caliper width of 0.2 standard deviations of the propensity score of the matched-II control group. After matching, we assessed the balance of covariates between the two groups using standardized mean differences, with values <0.1 indicating good balance. Details of the matching are available in section 6.0 Mahalanobis Distance within Propensity Score Calipers in Supplementary Material. We constructed 2×2 tables for each clinical outcome (mortality, complications during hospitalization, and aftercare) to compute the odds ratio (OR) and 95% confidence intervals (CI). The rate of hospital admission, modeling report card (Minitab® 18.1), and logistic regression for study outcomes are included in the Supplementary Material in Section 8.0. All analyses shared in the manuscript were conducted using NCSS 2024 (NCSS, LLC. Kaysville, Utah, USA; www.ncss.com/software/ncss).

Ethical Approval

This research adhered to the ethical guidelines outlined in the Declaration of Helsinki. The study was approved by the Institutional Review Board of the Dubai Scientific Research Ethics Committee (DSREC), supervised by the Dubai Health Authority (approval number: DSREC-02/2024_08). All patients involved in the study signed written informed consent during hospital admission.

Results

From March 1 2020 to December 31, 2022, 1243 patients with im-RD tested positive for COVID-19 through PCR testing. Of these patients, we excluded 1058 as they were not hospitalized. We excluded 53 patients because their underlying im-RD could not be classified using international classification standards. The remaining 132 patients were included. A summary of the im-RD diagnosis and management data is outlined in Supplementary Table S 5.1.

Based on the sample size calculation, outlined in section 3.0 sample size calculation in the Supplementary Material, we matched 132 patients with 264 age- and sex-matched patients without im-RD as controls. Patients with im-RD had a median age of 48.5 years (37.3–56 years), and the proportion of females was 74.2%; this was identical in matched-I; however, in matched-II control group had a median age of 48.6 years (38–55.8), and the proportion of females was 73.5%; however, this was not statistically significant. Table 1 summarizes the baseline characteristics of cases and controls.

COVID-19-Related Mortality and Morbidities

Patients with im-RDs (cases) exhibited higher COVID-19-related mortality rates (11.6%) compared to both control groups—matched-I (1.1%; OR: 11, 95% CI: 3–25.8, p < 0.000) and matched-II (0.8%; OR: 16.8, 95% CI: 2.2–35.5,

Table 1 Summary of the Baseline Demographic and Clinical Characteristics of the Study Participants with im-RMD and without im-RMD (Controls)

Variables	im-RMD (n = 132)	Matched-I (n = 264)	OR	95% CI	*p*-value	Matched-II (n = 132)	OR	95% CI	*p*-value
Age, median (IQR) years	48.5 (37.3–56)	48.5 (37.3–56)	-	-	1	48.6 (38–55.8)	-	-	0.9
Female, n (%)	98 (74.2)	196 (74.2)	1	0.6–1.6	1	97(73.5)	1.0	0.6–1.7	0.9
BMI, median (IQR)	30.7 (25.2–35.8)	28 (25.4–32.0)	-	-	0.1	30 (25.5–33.1)			0.4
Smoking, n (%)	8 (6.1)	15 (5.7)	1.1	0.5–2.6	0.8	7 (5.3)	1.2	0.4–2.9	0.8
Ethnicity									
Middle Eastern, n (%)	95 (72)	133 (50.4)	2.5	1.6–4.0	0.0001*	71 (53.8)	2.2	1.3–3.7	0.003*
South Asian, n (%)	25 (18.9)	72 (27.3)	0.6	0.4–1.0	0.08	34 (24.8)	0.7	0.4–1.2	0.2
Asian, n (%)	8 (6.1)	42 (15.9)	0.3	0.2–0.8	0.006*	20 (15.2)	0.4	0.2–0.9	0.03*
European, n (%)	1 (0.8)	12 (4.5)	0.2	0.02–1.2	0.07	4 (3)	0.2	0.03–2.2	0.4
African, n (%)	3 (2.3)	3 (1.1)	2	0.4–10	0.4	2 (1.5)	1.5	0.3–9.2	1
North America, n (%)	0 (0)	2 (0.8)	0.6	0.07–6.4	1	1 (0.8)	0.5	0.5–5.6	1
Cardiovascular diseases, n (%)	27 (20.5)	31 (11.7)	1.9	1.1–3.4	0.02*	18 (13.6)	1.6	0.8–3.0	0.2
IHD, n (%)	13 (9.9)	19 (7.2)	1.4	0.7–2.9	0.3	11 (8.3)	1.2	0.5–2.6	0.7
Cerebrovascular accident, n (%)	7 (5.3)	8 (3)	1.7	0.2–1.4	0.2	2 (1.5)	2.2	0.8–9.8	0.1
Heart failure, n (%)	5 (3.8)	10 (3.8)	1	0.4–2.9	0.9	5 (3.8)	1	0.3–3.0	1
Arrhythmia, n (%)	7 (5.3)	12 (4.6)	1.1	0.5–3.0	0.6	7 (5.3)	1	0.4–2.7	1
Cardiovascular risk factors	102 (77.3)	162 (61.4)	4.4	1.3–3.4	0.002*	101 (76.5)	1	0.6–1.8	0.9
Diabetes mellitus, n (%)	50 (37.9)	87 (32.95)	1.2	0.8–1.9	0.3	50 (37.9)	1	0.6–1.6	1
Hypertension, n (%)	61 (46.2)	86 (32.6)	3.7	1.2–2.7	0.008*	54 (40.9)	1.2	0.7–2	1.2
Hyperlipidemia, n (%)	37 (28)	40 (15.1)	2.2	1.3–3.6	0.002*	21 (15.9)	2.1	1.1–3.6	0.02*
Pulmonary comorbidities	38 (28.8)	32 (12.1)	2.9	1.7–4.9	0.0001*	28 (21.2)	1.5	0.9–2.6	0.2
Asthma +/ - COPD, n (%)	21 (15.9)	29 (11)	2.0	0.9–2.8	0.2	26 (19.7)	0.8	0.4–1.5	0.5
Interstitial lung diseases, n (%)	11 (8.3)	2 (0.8)	11	2.6–28.9	0.0001*	2 (1.5)	5.9	1.2–14.5	0.02*
Osteoporosis and/or fracture	22 (16.7)	12 (4.6)	4.2	2–8.1	0.0001*	6 (4.6)	4.2	1.6–8.9	0.002*
Osteoporosis, n (%)	19 (14.4)	12 (4.6)	3.5	1.6–7	0.0006*	6 (4.6)	3.7	1.3–7.6	0.008*

(*Continued*)

Table 1 (Continued).

Variables	im-RMD (n = 132)	Matched-I (n = 264)	OR	95% CI	*p*-value	Matched-II (n = 132)	OR	95% CI	*p*-value
Fragility fracture, n (%)	11 (8.3)	4 (1.5)	5.9	1.8–14.3	0.001*	1 (0.8)	3.9	1.6–26.3	0.006*
Infectious comorbidities	16 (12.1)	8 (3)	4.4	1.8–9.4	0.0004*	8 (6)	2.1	0.8–4.6	0.1
Tuberculosis, n (%)	9 (6.8)	1 (0.4)	19.2	2.5–43.8	0.0002*	1 (0.8)	9.6	1.2–21.9	0.02*
Hepatitis B, n (%)	0 (0.0)	1(0.4)	1	0.1–11	1	1 (0.8)	0	0.06–3.8	0.6
Hepatitis C, n (%)	3 (2.3)	1(0.4)	2.5	0.9–19.2	0.08	1 (0.8)	3	0.4–9.6	0.4
Herpes Zoster, n (%)	6 (4.6)	5 (1.9)	2.2	0.8–6.9	0.8	5 (3.8)	1.2	0.4–3.4	0.8
Malignancy and Depression, n (%)	14 (10.6)	25 (9.5)	1.1	0.6–2.3	0.7	8 (6)	1.8	0.8–4.1	0.2
Malignancy, n (%)	6 (4.6)	10(3.8)	1.2	0.5–3.3	0.6	4 (3)	1.5	0.4–4.4	0.6
Depression, n (%)	8 (6.1)	15 (5.7)	1.1	0.5–2.6	0.8	4 (3)	1.6	0.6–5.4	0.3
CKD, n (%)									
Stage 1	98 (74.2)	217 (82.2)	0.6	0.4–1	0.1	104 (78.8)	0.8	0.4–1.4	0.5
Stage 2	11 (8.3)	31 (11.7)	0.7	0.3–1.4	0.4	16 (12.1)	0.7	0.3–1.5	0.4
Stage 3	10 (7.6)	8 (3)	2.6	1.0–6.8	0.07	5 (3.8)	2.1	0.7–6.3	0.3
Stage 4	7 (5.3)	6 (2.3)	2.4	0.8–7.3	0.1	5 (3.8)	1.4	0.4–4.6	0.8
Stage 5	6 (4.6)	2 (0.8)	6.2	1.2–31	0.02*	2 (1.5)	3.1	0.6–16	0.3

Notes: *Statistically significant p < 0.05. Statistical tests, Fisher's exact tests for categorical variables and ANOVA for continuous variables.
Abbreviations: im-RMD, Immune-Mediated Rheumatic Disorders; n, Number; (%), percentage; IQR, Interquartile range; OR, Odds ratio; 95% CI, 95% Confidence Interval; IHD, Ischemic Heart Disease; COPD, Chronic Obstructive Pulmonary Disease; Tuberculosis, active and latent; TB, Tuberculosis; CKD, Chronic Kidney Disease.

p < 0.006). Similarly, patients with im-RDs had a higher rate of COVID-19-related complications compared to the controls (matched-I: OR = 2.4, 95% CI: 1.5–3.6, p < 0.00001; matched-II: OR = 2.8, 95% CI: 1.5–3.9, p < 0.0001. The most frequent complications in the cases were pneumonia, secondary infection, and immune thrombocytopenia (Table 2).

Notably, serious COVID-19 comorbidities were more common in patients with im-RDs than in matched-I controls. These included: cardiovascular complications (OR = 14.7, 95% CI: 2–35.3, p < 0.002), acute respiratory failure (OR = 2.9, 95% CI: 1.2–6.7, p = 0.02), acute kidney injury (OR = 3.7, 95% CI: 1.3–7.2, p < 0.009), neurological complications (OR = 10, 95% CI: 1.2–90, p < 0.02), septic shock (OR = 7.3, 95% CI: 1.5–19.6, p < 0.005), fungal infections (OR = 7.3, 95% CI: 1.8–21.9, p < 0.002), and pregnancy-related complications (OR = 13.7, 95% CI: 1.7–34.7, p < 0.004). However, when compared with matched-II controls, the differences in these complication rates did not reach statistical significance (all p > 0.05). Nevertheless, the percentage of overall vaccinated patients and the proportion of patients who acquired

Table 2 A Summary of Post-COVID-19 Clinical Outcomes in Patients with im-RMD and the Control Groups

Variables	im-RMD (n = 132)	Matched-I (n = 264)	OR	95% CI	*p*-value	Matched-II (n = 132)	OR	95% CI	*p*-value
Death, n (%)	15 (11.4)	3 (1.1)	11.2	3.0–25.8	0.00001*	1 (0.8)	16.8	2.2–35.5	0.006*
ICU admission, n (%)	14 (10.6)	11 (4.2)	2.7	1.2–5.8	0.01*	7 (5.3)	2.1	0.8–4.7	0.1
High flow oxygen, n (%)	17 (12.9)	19 (7.2)	1.9	0.05–3.7	0.06	12 (9.1)	1.5	0.6–3.0	0.3
Non-invasive	10 (7.6)	6 (2.3)	3.5	1.3–8.5	0.01*	6 (4.6)	1.7	0.6–4.2	0.3
Intubation, n (%)	12 (9.1)	7 (2.7)	4	1.4–8.4	0.005*	4 (3)	3.2	1.0–7.6	0.051
Tracheostomy, n (%)	5 (3.8)	3 (1.1)	3.4	0.9–10.3	0.07	2 (1.5)	2.6	0.3–7.6	0.3
ECMO, n (%)	1 (0.8)	0 (0)	4	0.4–45	0.3	0 (0)	2	0.2–23	1
Dialysis, n (%)	8 (6)	2 (0.8)	8	1.8–21.9	0.002*	2 (1.5)	4.2	0.9–11	0.08
Covid-19 complications, n (%)	83 (62.9)	98 (37.1)	2.9	1.8–4.3	0.00001*	50 (37.8)	2.8	1.7–4.5	0.0001*
Pneumonia, n (%)	77 (58.3)	98 (37.1)	2.4	1.5–3.6	0.0001*	48 (36.4)	2.5	1.5–3.9	0.0004*
Thrombotic event, n (%)	0 (0)	1 (0.4)	1	0.9–11	1	0 (0)	2	0.12–32	1
Cardiovascular, n (%)	7 (5.3)	1 (0.4)	14.7	2–35.3	0.002*	1 (0.8)	2.7	1–17.7	0.053
Acute respiratory failure, n (%)	11 (8.3)	8 (3)	2.9	1.2–6.7	0.02*	5 (3.8)	2.3	0.8–5.6	0.14
Acute respiratory distress syndrome, n (%)	10 (7.6)	9 (3.4)	2.3	1–5.3	0.6	5 (3.8)	2.1	0.7–5.1	0.22
Acute Kidney Injury, n (%)	12 (9.1)	8 (3)	3.7	1.3–7.2	0.009*	5 (3.8)	2.5	0.9–6	0.1
Acute Liver Injury, n (%)	2 (1.5)	1 (0.4)	4	0.5–15.2	0.2	0	3	0.3–29	0.6

(*Continued*)

Table 2 (Continued).

Variables	im-RMD (n = 132)	Matched-I (n = 264)	OR	95% CI	*p*-value	Matched-II (n = 132)	OR	95% CI	*p*-value
Pancreatic injury, n (%)	0	0	2	0.6–16	1	0 (0)	1	0.1–16	1
Neurological, n (%)	4 (3)	0 (0)	10	1.2–90	0.02*	0 (0)	5.2	0.6–45	0.2
Secondary infection, n (%)	24 (18.2)	13 (4.9)	4.3	2.1–8.2	0.0001*	5 (3.8)	5.1	2–12	0.0003*
Septic shock, n (%)	7 (5.3)	2 (0.8)	7.3	1.5–19.6	0.005*	1 (0.8)	7.3	1–17.7	0.053
Fungal infection, n (%)	8 (6)	2 (0.8)	7.3	1.8–21.9	0.002*	2 (1.5)	4.2	0.9–11	0.08
Immune thrombocytopenia, n (%)	15 (11.4)	5 (1.9)	5.7	2.3–14.9	0.000*	1 (0.8)	16.8	2.2–35.6	0.0006*
Disseminated intravascular coagulation, n (%)	4 (3)	2 (0.8)	4.1	0.9–13.1	0.08	1 (0.8)	4.1	0.6–11.6	0.3
Cytokine release syndrome, n (%)	3 (2.3)	9 (3.4)	0.7	0.2–2.4	0.7	6 (4.6)	0.5	0.2–1.8	0.4
Pregnancy-related complications, n (%)	6 (13.3)	1 (1.1)	13.7	1.7–34.7	0.004*	0 (0)	7.3	0.9–60	0.07

Note: *Statistically significant $p < 0.05$, Statistical tests; Fisher's exact tests for categorical variables and ANOVA for continuous variables.
Abbreviations: im-RMD, Immune-Mediated Rheumatic Disorders; n, Number; (%), percentage; OR, Odds Ratio; 95% CI, 95% Confidence Interval; IQR, Interquartile range. ICU, Intensive Care Units; ECMO, Extracorporeal Membrane Oxygenation.

COVID-19 infection following vaccination were comparable in both cases and controls. Details on COVID-19 vaccination in the entire sample are listed in Supplementary Table S 5.2.

Hospitalization

In terms of duration of hospitalization, patients with im-RD experienced significantly longer hospital stays than matched-I controls (median [IQR] = 8 (5–14) days versus 6 (3–10.9) days, respectively; $p < 0.002$). However, the differences were not statistically significant when compared to matched-II controls (median [IQR] = 7 (3.5–12) days; $p = 0.052$). Similarly, patients with im-RD had significantly higher rates of intensive care unit hospitalization (ICU) than the matched-I control ($p < 0.01$); however, there were no statistically significant differences between cases and matched-II controls ($p = 0.1$). ICU admission rates were significantly higher in patients with im-RD than in matched-I controls but not in matched-II controls; these rates were correlated with higher procedure rates performed in critical care settings, namely CRRT, noninvasive ventilation, and intubation. Surprisingly, patients with im-RD required less prone positioning than the matched-I control group (OR = 0.5, 95% CI: 0.3–0.9, $p < 0.01$) and matched-II controls (OR = 0.4, 95% CI: 0.2–0.7, $p < 0.001$).

The medications used to treat COVID-19 were comparable among patients and controls. However, there was a significant difference in the use of corticosteroids. More patients with im-RD received dexamethasone than matched-I controls (OR = 2.2, 95% CI: 1.3–3.8, $p < 0.003$) and matched-II controls (OR = 1.7, 95% CI: 1.1–2.7, $p = 0.05$), whereas the use of hydrocortisone and/or prednisolone was significantly higher in patients with im-RD than the matched-I controls but not the matched-II controls.

Care After Discharge

Patients with im-RD required more COVID-19 im-RD clinic visits than matched-I controls (mean difference = 23.9%) and matched-II controls (mean difference = 28.1%) ($p < 0.000$). The difference was particularly noticeable in specialty clinic visits, with im-RD patients attending 37.9% more often than matched-I controls and 37.1% more often than matched-II controls ($p < 0.000$).

Furthermore, patients with im-RD more frequently required dialysis after discharge compared to the matched-I control group (6.1% versus 0.8%; $p < 0.003$) but not to the matched-II control group im-RD (6.1% versus 1.5%, $p = 0.1$). Unexpectedly, the need for home nursing care and the readmission rate within one month of discharge were comparable among im-RD the cases and both control groups.

Health Economics

In terms of economic load, COVID-19 management expenses differed considerably between cases and controls. Patients with im-RD had significantly greater direct and indirect im-RD expenditure than both matched-I controls (AED 40,727

https://doi.org/10.2147/OARRR.S510631

Table 3 Total Expenses for the Management of COVID-19 in the im-RMD and the Control Groups

Variables	im-RMD (n = 132)	Matched-I (n = 264)	OR	95% CI	*P*-value	Matched-II (n = 132)	OR	95% CI	*P*-value
Length of hospital stay, median (IQR) days	8 (5–14)	6 (3–10.9)	–	–	0.002*	7 (3.5–12)	–	–	0.052
Overall Cost of COVID-19 infection, median (IQR), AED	40,727 (29,245–60,981)	29,098 (23,464–39,960)	–	–	<0.0001*	29,895 (25,179–40,684)	–	–	<0.0001*
Direct Cost, median (IQR), AED	29,386 (17,471–39,036)	17,471 (11,832–29,386)	–	–	<0.0001*	17,471 (12,161–29,386)	–	–	0.0002*
Indirect Cost, median (IQR), AED	12,676 (10,574–17,840)	11,103 (9,252–13,217)	–	–	<0.0001*	11,490 (9,512–13,746)	–	–	0.0002*
Exceeded the expected DRG length of stay, n (%)	54 (40.9)	83 (31.4)	1.5	1–2.3	0.08	46 (34.8)	1.3	0.8–2.1	0.4
Readmission within one month of discharge, n (%)	7 (5.3)	12 (4.5)	1.2	0.5–3.1	0.8	5 (3.5)	1.4	0.4–4.6	0.8
Sick leave days, median (IQR) days	22 (19–28)	20 (17–25)	–	–	0.003*	21 (17–26)	–	–	0.03*
Estimate loss of productivity, median (IQR), AED	11,632 (10,046–14,804)	10,574 (8,988–13,152)	–	–	0.002*	11,103 (9,252–13,746)	–	–	0.02*
Aftercare									
COVID-19 clinic visits, n (%)	67 (50.8)	71 (26.9)	2.8	(1.8–4.3)	<0.0001*	30 (22.7)	3.5	(2.1–6.0)	<0.0001*
Specialty clinics, n (%)	64 (48.5)	28 (10.6)	7.9	(4.7–13)	<0.0001*	15 (11.4)	7.3	(3.9–14)	<0.0001*
Dialysis post-discharge, n (%)	8 (6.1)	2 (0.8)	8.5	(1.8–40)	0.003*	2 (1.5)	4.2	(0.9–20)	0.1
Full-time Nursing care, n (%)	4 (3)	2 (0.8)	4.1	(0.7–23)	0.1	2 (1.5)	2	(0.3–11)	0.7

Notes: *Statistically significant p <0.05, Statistical tests: Fisher's exact tests for categorical variables and ANOVA for continuous variables.

Abbreviations: im-RMD, Immune-Mediated Rheumatic Disorders; n, Number; (%), percentage; IQR, Interquartile Range; OR, Odds Ratio; 95% CI, 95% Confidence Interval; DRG, Diagnosis-Related Group.

vs AED 29,098; $p < 0.001$) and matched-II controls (AED 40,727 vs AED 29,684; $p < 0.001$). Table 3 summarizes the total expenses for the management of COVID-19 in the three groups.

Furthermore, the impact of COVID-19 extended beyond the hospital stay for im-RD patients. The number of sick leave days was significantly higher in the im-RD group than in both control groups. Consequently, the estimated loss of productivity was also significantly higher in im-RD patients than in controls.

Discussion

This study compared the impact of severe COVID-19 infection in patients with im-RD to age- and sex-matched controls without im-RD. We explored the clinical and financial burden of COVID-19 and the utilization of health resources in both groups, and we observed that patients with im-RD experienced significantly higher rates of COVID-19-related deaths and complications, requiring more healthcare resources im-RD.

While the higher mortality rates in patients with im-RD observed in our study concur with several published reports,[9,12] other reports showed no significant differences in COVID-19-related deaths between patients with im-RD and the general population.[14,18,20] This inconsistency may be attributed to the differences in study populations, healthcare systems, and patients' disease activity levels. Moreover, pre-existing comorbidities, immunosuppressive medications, and overall health status are likely to play a crucial role in determining COVID-19 clinical outcomes.

Overall, the mortality rate in our study population was lower than what is reported in a meta-analysis of 42 studies involving 423,117 patients, which found a mortality rate of 17.62% (95% CI 14.26–21.57%) with high heterogeneity (^{2}= 100%).[34] Our results reflect the healthcare provided in the country during the pandemic, which made the United Arab Emirates one of the countries with a low COVID-19 mortality rate.[35] Indeed, several factors can influence mortality rates, such as testing strategy, demographics, healthcare system capacity, and accessibility to care.

Most of the deaths in our cohort occurred between Q1 2021 and Q1 2022 in patients with im-RD (Figure 7.1 in the Supplementary Material), despite improvements in supportive care, the availability of antiviral drugs, and a similar COVID-19 vaccination rate compared to the control group (Table S5.2). This raises concerns regarding im-RD-related factors, such as active disease before COVID-19 hospitalization, which could have been exacerbated by delayed or canceled appointments with rheumatologists or non-compliance with disease-modifying antirheumatic drugs. This is supported by results from the COVID-19 Global Rheumatology Alliance physician-reported registry, which included 3729 patients from March 24 to July 1, 2020. The registry showed that patients with high disease activity had higher odds of death (OR: 1.87, 95% CI: 1.27–2.77) compared to those with low disease activity or in remission.[9]

We found significantly higher rates of pneumonia, secondary infections, and immune thrombocytopenia in patients with im-RD compared to controls. Previous studies have also indicated that patients with im-RD are at a higher risk for various COVID-19-related complications, such as pneumonia and secondary infections, compared to the general population im-RD.[36–39] While less frequently documented, certain case reports and systematic reviews support our findings of increased immune thrombocytopenia[40,41] and cardiovascular complications[42] in patients with im-RD. The lack of differences between patients with im-RD and matched control-II indicates that the established risk factors of age, sex, comorbidities, smoking, and BMI play a more significant role in cardiovascular risk than im-RD alone. Similarly, other complications were significantly higher in patients with im-RD compared to matched-I control but not with matched-II, indicating that the matching criteria used in the matched-II controls may have addressed significant confounding variables affecting the risk of these complications in im-RD patients with COVID-19.

The hospital admission rate among screened COVID-19 patients in our study was 14.9% for im-RD patients and 10.4% for controls, with a calculated odds ratio of 1.5 (95% CI 1.3–1.8). Our findings are similar to those reported in a large cohort study that included 17,672,065 adult patients, analyzing routinely collected primary care data linked to hospital admission and death. The hazard ratio for COVID-19 admission in patients with inflammatory joint disease was 1.53 (95% CI 1.47–1.59) compared to the general population.[15] However, a meta-analysis that included 100 studies, 70 of which compared the hospitalization rate in patients with im-RD to those without im-RD, found that the relative risk for hospitalization was lower than what we reported, with a random-effects estimate of 1.25 (95% CI 0.68–2.3).[43] This discrepancy can be attributed to the high heterogeneity (I^2 = 89%) across the studies.

Another important finding of our study was that patients with im-RD had significantly longer hospital stays than matched-I controls (Figure 7.2 in the Supplementary Material). This extended hospitalization period may indicate a more severe disease course and, possibly, the need for more complex care in im-RD patients, particularly considering different age groups and sex. However, this difference resolved when compared with a control with matched comorbidities, indicating that the comorbidity profile at baseline determines the length of stay in patients with severe COVID-19. A similar pattern was seen with ICU admission and mechanical ventilation use.[19]

More patients with im-RD received dexamethasone compared to both control groups. Previous studies have shown that dexamethasone reduces mortality in patients with COVID-19 who require any form of respiratory support (noninvasive or mechanical) but not in patients who do not receive any respiratory support.[44] The higher proportion of im-RD patients requiring noninvasive and mechanical ventilation during admission may explain the greater proportion receiving dexamethasone for treatment.

It is worth mentioning that there is a strong association between gout and adverse COVID-19 outcomes due to its known link with metabolic syndrome,[45] which introduces a potential confounder in the control groups. However, there were no gout patients in the selected controls, and we addressed this potential risk by using propensity score matching for cardiometabolic disorders.

We also found increased healthcare resource utilization postdischarge among patients with im-RD compared with the control groups. This can be explained partly by previously reported findings, which showed that 25% of patients with im-RD infected with COVID-19 had persistent COVID-19 symptoms beyond 28 days and 10% of these patients may continue to have symptoms beyond 90 days.[46] Furthermore, in our study, the rate of complications, especially respiratory, was higher among patients with im-RD than the control groups; hence, a significantly higher proportion of im-RD these patients needed clinical visits to different specialists. Similar to our study, several studies[18] did not observe a significant difference between patients with im-RD and controls in terms of readmission rate postdischarge, (Figure 7.3 in the Supplementary Material) probably because of the high prevalence of long COVID among the general population as well.[47]

Notably, the overall costs of COVID-19 infection varied significantly between im-RD and the control groups despite a similar hospital length of stay and comparable proportions of patients exceeding the expected DRG length of stay. Patients with im-RD incurred substantially higher direct and indirect costs than both control groups, (Figure 7.4 in the Supplementary Material). Similarly, a Brazilian study that looked at 3254 COVID-19 admissions reported that patients with im-RD had higher average admission costs than patients with other comorbidities.[48] The greater direct cost in patients with im-RD could be attributed to heightened vigilance by both patients and healthcare providers who are more cautious about potential complications,[14] leading to more investigations. Furthermore, COVID-19 could exacerbate co-existing comorbidities in im-RD during hospitalization im-RD requiring additional care. The high complication rates observed in our study were similar to previous ones and warrant the implementation of additional treatment measures.

The financial impact of COVID-19 extended beyond the hospital stay for im-RD patients, resulting in higher indirect costs. Sick leave was significantly more prevalent in the im-RD group than in both control groups, which is similar to previous studies.[49,50] This may be due to the reported higher prevalence of post-COVID-19 syndrome in patients with im-RD than in the general population.[46] Additionally, this group has a higher rate of post-COVID-19 infection problems and requires strict outpatient follow-up, which increases the patient's financial burden. Consequently, the calculated loss of productivity was higher in patients with im-RD and COVID-19 than that in controls. Nevertheless, there is an opportunity to provide cost-effective healthcare post-COVID-19 hospital release to patients with im-RD including: (a) Telemedicine: regular remote follow-up visits to detect early signs of illness. (b) Multidisciplinary approach: coordinate care across disciplines and guarantee comprehensive follow-up without duplicating. (c) Home-based care: use of home health care and related services and rehabilitation if necessary. (d) Medication reconciliation: perform complete medication evaluations after discharge to avoid adverse outcomes. (e) Patient self-management assistance: provide tools and information for self-monitoring symptoms and disease activity. (f) Develop techniques to detect and manage long-term COVID-19 symptoms in patients with im-RD.

Our study found compelling evidence supporting the fact that patients with im-RD and COVID-19 experience higher death rates and disease complications than controls. Moreover, this group requires more healthcare resources after

discharge. These findings may have a major impact on the treatment of patients with im-RD and COVID-19 infection. In other words, patients with im-RD and COVID-19 have a higher mortality rate and comorbidities that demand an aggressive therapeutic strategy. Therefore, physicians should implement tailored COVID-19 treatment protocols for this special group, attending for active monitoring and earlier interventions to reduce risks of morbidity and mortality. Our results also underscore the importance of preventive measures and timely medical consultation for patients with im-RD and their caregivers. Additionally, physicians should also plan for extended hospital stays and offer more intensive treatment. Furthermore, because of higher complication rates, physicians must develop and implement protocols for long-term care and follow-up strategies following hospital discharge.

Our findings also highlight a potential issue for im-RD healthcare policymakers. In this regard, because of economic burden, the allocation of resources must evolve, including, hospital beds, ICU capacity, and specialized equipment, as well as planning healthcare budgets and insurance coverage. Policymakers should prioritize this special group in terms of vaccination campaigns and booster programs. There is also a need for targeted public health messaging to this population. Therefore, future research should focus on optimizing COVID-19 management in patients with im-RD and developing targeted therapies. These results emphasize the need to enhance healthcare systems to address the specific needs of this patient group during endemic outbreaks.

A significant strength of our study is the comparison of patients with im-RD with controls matched for age, sex, comorbidity profile, smoking status, and BMI, which minimized potential confounding variables. We recruited the cases and controls from a single center to ensure that patients received a standardized level of care according to the severity of COVID-19 infection during the pandemic. Furthermore, we have reported detailed information on direct and indirect costs, which enables local authorities and health economists to use these data in a bottom-up approach for estimating the cost of illness in future research.[51] Our study is the first in the region to compare patients with COVID-19 and im-RD with matched controls. However, the retrospective study design limited our capacity to collect data from disease onset and reduce reporting bias. Although the UAE government covered COVID-19 treatment costs for all nationals and residents during the pandemic,[52] ethnic disparities between im-RD cases and controls may have affected some outcomes. Furthermore, the small number of COVID-19-related deaths in our cohort prevented us from identifying predictors of mortality in im-RD patients.[53] Another limitation of our study was that it is a single-center design, which contrasted with the national data. This could have resulted in left censoring bias for patients and controls who received treatment and/or vaccination outside Dubai, affecting the accuracy of data obtained from EMRs.

More comprehensive registries from the Middle East are needed to understand the complex link between im-RD and COVID-19, as well as their clinical outcomes; assess their progression, disability, and cost; and develop preventive strategies and management techniques. There is also a lack of particular research on quality-adjusted life years in patients with im-RD after severe COVID-19 infection, an aspect that requires future research to better understand the long-term impact of severe COVID-19 in this population.

Conclusion

Patients with im-RD and severe COVID-19 have higher morbidity and mortality rates, resulting in a greater clinical and financial burden on patients, the healthcare system, and the government. This study highlights the need for tailored COVID-19 treatment protocols, preventive measures, and long-term care strategies for patients with im-RD. The findings also emphasize the importance of resource allocation and targeted public health messaging for this population, as well as the necessity for future research to optimize COVID-19 management in patients with im-RD.

Data Sharing Statement

All data generated or analyzed during this study are included in this published article (and its Supplementary Information Files).

Ethics Approval and Informed Consent

This research adhered to the ethical guidelines outlined in the Declaration of Helsinki. The study was approved by the Institutional Review Board of the Dubai Scientific Research Ethics Committee (DSREC), supervised by the Dubai Health

Authority (approval number: DSREC-02/2024_08). All patients involved in the study signed written informed consent during hospital admission.

Acknowledgments

We would like to thank Mrs. Smitha Sudarsanan, RCM Manager, Health Insurance & RCM Department, Dubai Hospital, Dubai Health, for her support in obtaining the codes and the direct and indirect costs of recruited patients with COVID-19 infections, Mrs. Ansu Anna Johan who was essential in providing logistical support, and patients who agreed to use their data anonymously. The authors would like to thank Enago (www.enago.jp) for the English language review.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This research has been funded by an unrestricted educational grant reference number (SAF_2023_583) from AstraZeneca UK LTD.

Disclosure

The authors report no conflicts of interest in this work.

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