Risk and prognosis of SARS-CoV-2 infection and vaccination against SARS-CoV-2 in rheumatic and musculoskeletal diseases: a systematic literature review to inform EULAR recommendations

Féline P.B. Kroon[1], Aurélie Najm[2], Alessia Alunno[3], Jan W. Schoones[4], Robert B.M. Landewé[5], Pedro M. Machado[6], Victoria Navarro-Compán[7]**

*Shared last authorship

[1]MD, PhD; Department of Rheumatology, Leiden University Medical Center, Leiden, The Netherlands & Zuyderland Medical Center, Heerlen, The Netherlands

[2]MD, PhD; Institute of Infection, Immunity and Inflammation, College of Medical Veterinary and Life Sciences, University of Glasgow, Glasgow, UK

[3]MD, PhD; Internal Medicine and Nephrology Unit, Department of Life, Health and Environmental Sciences, University of L'Aquila, L'Aquila, Italy

[4]MA; Directorate of Research Policy (formerly: Walaeus Library), Leiden University Medical Center, Leiden, Netherlands

[5]MD, Professor of Rheumatology; Department of rheumatology & clinical immunology, Amsterdam University Medical Center & Zuyderland Medical Center, Heerlen, The Netherlands

[6]MD, PhD; Department of Rheumatology, Northwick Park Hospital, London North West University Healthcare NHS Trust, London, UK & Centre for Rheumatology & Department of Neuromuscular Diseases, University College London, London, UK & National Institute for Health Research (NIHR) University College London Hospitals (UCLH) Biomedical Research Centre (BRC), University College London Hospitals (UCLH) NHS Foundation Trust, London, UK.

[7]MD; PhD; Rheumatology Department, University Hospital La Paz, IdiPaz, Madrid, Spain

Corresponding author: Féline P.B. Kroon, Department of Rheumatology, Leiden University Medical Center, Leiden, The Netherlands & Zuyderland Medical Center, Heerlen, The Netherlands. E-mail address: fpbkroon@gmail.com.

Word count: 5013

ABSTRACT

Objectives. Perform a systematic literature review (SLR) on risk and prognosis of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection and vaccination against SARS-CoV-2 in patients with rheumatic and musculoskeletal diseases (RMDs).

Methods. Literature was searched up to 31 May 2021, including (randomised) controlled trials and observational studies with RMD patients. Pending quality assessment, data-extraction was performed and risk of bias (RoB) assessed. Quality assessment required provision of (i)an appropriate COVID-19 case definition, and (iia)a base incidence (for incidence data), or (iib)a comparator, >10 cases with the outcome and risk estimates minimally adjusted for age, sex and comorbidities (for risk factor data).

Results. Of 5,165 records, 208 were included, of which 90 passed quality assessment and data were extracted for incidence (n=42), risk factor (n=42) or vaccination (n=14). Most studies had unclear/high RoB. Generally, patients with RMDs do not face more risk of contracting SARS-CoV-2 (n=26 studies) or worse prognosis of COVID-19 (n=14) than individuals without RMDs. No consistent differences in risk of developing (severe) COVID-19 were found between different RMDs (n=19). Disease activity is associated with worse COVID-19 prognosis (n=2), possibly explaining the increased risk seen for glucocorticoid use (n=13). Rituximab is associated with worse COVID-19 prognosis (n=7), and possibly Janus kinase inhibitors (n=3). Vaccination is generally immunogenic, though antibody responses are lower than in controls. Vaccine immunogenicity is negatively associated with older age, rituximab and mycophenolate.

Conclusion. This SLR informed the July 2021 update of the EULAR recommendations for the management of RMDs in the context of SARS-CoV-2.

Keywords: COVID-19, systematic literature review, management

INTRODUCTION

In April 2020, EULAR commissioned provisional recommendations for the management of patients with rheumatic and musculoskeletal diseases (RMDs) in the context of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus, causing the disease COVID-19, which has gripped the world since December 2019.[1] In the absence of an evidence base to inform those recommendations, those statements were based largely on expert opinion. However, the number of publications in this field has grown exponentially since then. In light of the newly accrued data with the opportunity to provide evidence-based guidance, it was therefore time to update the April 2020 recommendations. This paper presents the systematic literature review (SLR) on risk and prognosis of SARS-CoV-2 infection and vaccination against SARS-CoV-2 in patients with RMDs that accompanies the July 2021 update of the recommendations.

METHODS

Research questions

This SLR was used to inform the EULAR task force for the July 2021 update of the recommendations for the management of RMDs in the context of SARS-CoV-2. The task force outlined the scope of the literature search by defining five research questions according to the PICO format (Participants, Interventions, Comparators, Outcomes; see Supplementary material)[2]:

(1) Do patients with RMDs face more risk of contracting SARS-CoV-2?

(2) Do patients with RMDs have a worse prognosis when contracting SARS-CoV-2?

(3) In patients with RMDs who contract SARS-CoV-2, is antirheumatic medication associated with a worse outcome?

(4) Should patients with RMDs who contract SARS-CoV-2 continue their drug treatment?

(5) What evidence informs the use of vaccination against SARS-CoV-2 in patients with RMDs?

Effects of the SARS-CoV-2 pandemic on the referral and monitoring of patients with RMDs (e.g., (postponement of) regular blood monitoring and face-to-face consultation) were not included as a separate research question, as this will be investigated by a separate EULAR task force.

Literature search

A systematic search was conducted in PubMed/MEDLINE, Embase, Cochrane CENTRAL and the World Health Organisation (WHO) COVID-19 databases up to 31 May 2021 by an experienced librarian (JS). Additionally, conference abstracts of the EULAR 2021 annual conference were screened. No language restrictions were applied. Papers only published on a pre-print server were excluded, unless they provided evidence on vaccination (in order not to miss relevant studies on this novel subject). The search strategy can be found in the online Supplementary material.

The review focused on available evidence specifically in patients with RMDs, and was not intended to summarize evidence for the prevention, diagnosis, treatment or prognosis of SARS-CoV-2 infection in the general population. While the EULAR recommendations will focus primarily on the management of patients with autoimmune inflammatory rheumatic diseases (AIIRD), studies including patients with other types of ('non-inflammatory') RMD were not excluded. Studies including participants with non-RMD diagnoses were only eligible if the results were presented separately for participants with RMDs, or if ≥75% of the study population had an RMD.

Studies with a comparator were viewed higher in the hierarchy of evidence, though studies without a comparator were not a priori excluded. All outcomes relevant for the research questions were extracted without specific hierarchy.

Eligible study types were (randomised and non-randomised) controlled trials (RCT/CCT) and observational studies (cohort, case-control, cross-sectional; prospective or retrospective, including registries). The following hierarchy of study design was adopted: RCT/CCT, prospective observational longitudinal cohort study, retrospective observational longitudinal cohort study, case-control study, cross-sectional study.

Studies were excluded when the number of participants was lower than 75 (arbitrary cut-off), with the exception of studies on vaccination against SARS-CoV-2. Studies that were not published as a full-text manuscript were only eligible if the authors provided sufficient data to extract information on the population, intervention, comparator and study outcomes.

Study selection, data-extraction and risk of bias assessment

Two reviewers (FK and AA/AN) independently screened titles and abstracts, and thereafter the full-text for eligibility. The same reviewers performed a quality assessment of included studies, based on predefined criteria set by the steering group as minimal requirements to

justify data-extraction. All studies were required to have an appropriate case definition of COVID-19, defined as a positive SARS-CoV-2 Polymerase Chain Reaction (PCR+) test, serological antibody response, typical imaging abnormalities on X-ray or computed tomography (CT), physician diagnosis, International Classification of Diseases (ICD)-10 diagnostic code or fulfilment of WHO diagnostic criteria set. Studies with data on incidence of COVID-19 in a RMD population or prevalence of RMDs in a COVID-19 population were required to report a base incidence of the outcome in the base population (i.e., population from which the study was sampled) to be able to compare the reported and the base incidence. Studies with data on risk factors for development or worse prognosis of COVID-19 were required to (i) include a comparator, (ii) have at least 10 cases with the outcome, and (iii) provide risk estimates at least adjusted for age, sex and comorbidities.

Data from eligible studies were extracted by one reviewer (FK) and verified by a second (AA/AN) using a standardised data-extraction form.

Risk of bias (RoB) of all studies was assessed in duplicate by a junior (AA/AN/FK) and senior (PM/RL/VN-C) reviewer, using an appropriate tool depending on the study type: Newcastle-Ottawa Scale was used for longitudinal observational cohort and case-control studies,[3] and the AXIS-tool was used for cross-sectional studies.[4] For the final RoB judgment, an additional weighting was applied, in which studies were *not* rated low risk of bias when: (i) possible selection bias had not been recognised and somehow adjusted for, (ii) selection bias was irreparable by design (e.g., voluntary enrolment of SARS-CoV-2-positive cases), or (iii) ascertainment of cases, exposure or outcome was uncertain.

For study selection, quality assessment, data-extraction and RoB assessment, disagreements were discussed until consensus was reached, and a third reviewer (PM/RL/VN-C) was involved whenever necessary.

RESULTS

Of 5,165 records (after deduplication), 501 were selected for full-text review and 208 articles were included (see flowchart in Supplementary Figure 1). Of these, 90 articles passed quality assessment and were eligible for data-extraction of incidence data (n=42), risk factor data (n=42) or vaccination data (n=14). The most important reasons for a negative quality assessment were lack of a base incidence, having no comparator or presentation of risk estimates with no minimal adjustment for age, sex and comorbidities (see Supplementary Tables 1-2 for an overview of studies that did not pass quality assessment). The detailed RoB assessment is provided in Supplementary Tables 3-5.

Incidence of (severe) COVID-19 in patients with RMDs

Incidence of COVID-19

In total, 26 studies reported on the incidence of COVID-19 in patients with RMDs (Supplementary Table 6). Most (n=17) were cross-sectional studies, 8 were retrospective and one was a prospective study. Number of patients varied from 25[5] to 39,835[6] RMD patients with 1[7] to 199[8] COVID-19 cases. All but two studies were performed in the first wave of the pandemic.[9,10] Most studies included multiple inflammatory RMDs (n=13) or any type of RMD (n=5). COVID-19 diagnosis was defined as PCR+ (n=18), a combination of laboratory testing, imaging or symptoms (n=6), or through diagnostic criteria (n=2). RoB was high (n=15) or unclear (n=10) in most studies. The reported incidence of COVID-19 in patients with RMDs varied substantially (0.16% to 0.36%), with a similar variation in the base population. Compared to the general population, most studies reported an equal incidence (n=19), six reported a higher incidence (n=5 various RMDs, n=1 SLE patients) and one a lower incidence. Three studies assessed age- and sex-adjusted incidence rates,[11-13] of which one was at low RoB, reporting an equal incidence of COVID-19 in RMD patients and the general population.

Incidence of severe COVID-19

Eleven studies investigated the incidence of COVID-19 related hospitalisation (Table 1). All were retrospective studies, from the first wave of the pandemic. Study size varied from 8[14] to 110,567[15] RMD patients with 1[16] to 581[15] hospitalisations. Four studies had a high or unclear RoB, while three were at low RoB. The reported hospitalisation rate in patients with RMDs varied substantially (0.11% to 44%), as did the hospitalisation rate in the general population. Compared to the general population, six studies found a higher hospitalisation rate, while four studies reported an equal and one a lower incidence of hospitalisation. Only three studies (low RoB) investigated age- and sex-adjusted hospitalisation rates;[11,15,17] among these, Bower et al. found that the increased risk of hospitalisation for COVID-19 was comparable to the increased risk of all-cause hospitalisation in RMD patients.[15]

Six studies, five of which were retrospective and all conducted during the first wave of the pandemic, assessed the incidence of COVID-19 related death, including 8[14] to 110,567[15] RMD patients with 0[18] to 161[15] deaths (Table 1). Reported mortality rates in patients with RMDs varied considerably (0% to 22.6%), with similar variation observed in the general population. Studies demonstrated an equal (n=4) or lower (n=2) risk of COVID-19 related

death in RMD patients compared to the general population. Two studies with age- and sex-matched analyses reported an equal incidence rate, of which one was at low RoB.[15,19] Of note, although Bower et al. did report an increased risk of COVID-19 related death in the RA subgroup, they also demonstrated that this increased risk was comparable to the increased all-cause mortality risk in RA patients and that the increased mortality risk in 2020 in RA patients was not different from that in 2015 to 2019.

Finally, two studies reported on the risk of intensive care unit (ICU) admission, and found an equal[15] or lower[18] risk of ICU admission for COVID-19 in RMD patients compared to the general population (Table 1). A large Danish registry study (low RoB) found that the risk of 'severe COVID-19' (a composite outcome including several COVID-19 complications) was higher in RA patients compared to the general population, although the reported (non-significant) risk estimate did not seem to have a clinically relevant impact on a population-level (Table 1).[17]

Prevalence of RMDs in patients with COVID-19

Five studies (high RoB) investigated the prevalence of different RMDs in a COVID-19 population. Most report an equal prevalence of RMDs compared to the general population, though some found a higher prevalence (Supplementary Table 7).

Table 1. Studies with data on the incidence of severe COVID-19 in patients with RMDs compared to persons without RMDs

First author	Country	Cohort	Study period	Study type	Setting	Study population; recruitment	Case definition RMD	Case definition COVID-19	Source population of base incidence	Total (N)	Incidence in RMD patients	Base incidence	Incidence in RMD patients vs base population (higher, equal, lower)	RoB
I. Outcome: Hospitalisation for COVID-19														
Bachiller-Corral[20]	Spain	-	1 Mar to 30 Apr 20	Retrospective	Secondary care	Patients with inflammatory RMD in hospital area of care; hospital records	Physician diagnosis	PCR+ or typical imaging	Non-RMD population in hospital area of care	4,592	41/4,592 (0.89%) [all], 16/1,708 (0.94%) [RA], 3/862 (0.35%) [SpA], 4/515 (0.78%) [PsA], 4/254 (1.57%) [SLE], 4/175 (2.29%) [SjS], 3/165 (1.82%) [vasculitis], 1/88 (1.14%) [IM], 6/474 (1.27%) [PMR]	2,274/488,153 (0.47%)	Higher for all (OR 1.91, 1.41-2.61), RA (2.01, 1.23-3.28), SLE (3.38, 1.28-8.95), SjS (4.90, 1.86-12.94), vasculitis (3.90, 1.27-11.99), PMR (2.71, 1.23-6.02); Equal for SpA (OR 0.74, 0.24-2.31), PsA (1.66, 0.63-4.43), IM (2.43 (0.35-17.13)	
Bjornsson[11]	Iceland	ICEBIO	Until 3 Jun 20	Retrospective, registry, matched	Population-based	ts/bDMARD treated RMD patients and MTX treated RMD patients; data from national registries	Physician diagnosis	PCR+	General population registries, matched (age, sex, location)	39,961	3/9 (33%) [ts/bDMARD], 1/5 (20%) [MTX]	3/84 (3.6%) [ts/bDMARD controls], 13/134 (9.7%) [MTX controls]	Higher for ts/bDMARD (RR 9.33, 2.20-39.6) and MTX (6.22, 1.19-32.46)	
Bower[15]	Sweden	-	May to Sep 20	Retrospective, registry, matched	Population-based	Inflammatory arthritis patients; data from national registries	Physician diagnosis	ICD-10	General population registries, matched (age, sex, location)	110,567	581/110,567 (0.5%) [all], 379/53,455 (0.7%) [RA], 202/57,112 (0.4%) [other IJD]	1,443/484,277 (0.3%) [all controls], 784/484,277 (0.4%) [RA controls], 659/484,277 (0.3%) [other IJD controls]	Higher for all (fully adjusted HR 1.32, 1.19-1.46), RA (1.40, 1.22-1.60), other IJD (1.20, 1.02-1.41) Comparable to increased all-cause hospitalisation risk	
Comarmond[14]	France	-	4 May to 20 May 20	Retrospective	Secondary care	Patients with TAK or GCA; followed at outpatient clinic	Physician diagnosis	PCR+ or typical CT imaging or serology+	Modelled risk in country	148	3/8 (37.5%)	9.6% (age 70-79), 21% (age >80)	Higher	
Cordtz[17]	Denmark	DANBIO	1 Mar to 12 Aug 20	Retrospective, registry	Population-based	ts/bDMARD treated RA, SpA, CTD or vasculitis patients; data from national registries	Physician diagnosis	ICD-10	General population registries	58,052	69/58,052 (age- and sex-adjusted IR per 1000 py 1.73, 1.34-2.23)	2,536/4.5 mln (age- and sex-adjusted IR per 1,000 py 1.26, 1.21-1.31)	Higher (HR 1.46, 1.15-1.86)	
Fernandez-Gutierrez[21]	Spain	-	1 Mar to 15 Apr 20	Retrospective	Secondary care	Inflammatory RMD patients with COVID-19; all patients followed at outpatient clinic Mar 19 to Mar 20	ICD-10	PCR+ or physician diagnosis	General population in region	3,951 (5,896 patient-months)	54/3,951 (1.36%; cumulative incidence 15 per 1000 patients; IR 9.15 (7-11.9) per 1000 patient-months)	1,059/325,900 (cumulative incidence 3.2 per 1000 persons; IR 4.6 (3.4-6.1) per 1000 person-months)	Higher (p<0.001)	
Flood[22]	Ireland	-	Until 3 Jun 20	Retrospective	Secondary care	Patients with RMD; all patients followed at outpatient clinic	Physician diagnosis	PCR+ or physician diagnosis	General population in city	7,500	15% [Inflammatory RMD]	13%	Equal	
Jovani[23]	Spain	-	Until 2 May 20	Retrospective	Secondary care	ts/bDMARD treated RMD patients; followed at outpatient clinic	Physician diagnosis	PCR+	General population in city	1,037	3/1,037 (0.29%)	306/274,122 (0.11%)	Equal (OR 2.61, 0.84-8.16)	
Ramirez[16] (*COVID-19 in*)	Italy	-	17 Apr to 27 Apr 20	Retrospective	Secondary care	Patients with SLE; all patients followed at three outpatient clinics	Physician diagnosis	Self-reported PCR+	General population in region	417	1/417 (0.24%)	42,889 hospitalised (0.43%)	Equal	
Salvarani[5] (*Susceptibility and*)	Italy	-	Until 24 Apr 20	Retrospective	Secondary care	ts/bDMARD treated RMD patients; treated since Dec 19 (pharmacy data)	Physician diagnosis	PCR+	General population in region	1,195	4/9 (44.4%)	1,342/3,746 (35.8%)	Equal (p=0.73)	
Santos[24] *(Biological agents)*	Spain	-	NR	Retrospective	Secondary care	bDMARD treated RMD patients; treated between Dec 19 to Dec 20 (hospital records)	Physician diagnosis	PCR+	General population in region	820	4/820 (0.48%)	4,464 hospitalised (3.6%)	Lower	
II. Outcome: COVID-19 related death														
Aries[18]	Germany	Hamburg COVID-19 registry	Until 9 Jun 20	Cross-sectional, registry	Secondary care	DMARD treated RMD patients with COVID-19; cases reported by rheumatologists	Physician diagnosis	Symptoms and PCR+ or IgG+	General population in region	11,771	0/30 (0%)	226/5,120 (4.4%)	Lower	
Bower[15]	Sweden	-	May to Sep 20	Retrospective, registry, matched	Population-based	Inflammatory arthritis patients; data from national registries	Physician diagnosis	ICD-10	General population registries, matched (age, sex, location)	110,567	161/110,567 (0.1%) [all], 134/53,455 (0.3%) [RA], 27/57,112 (0.05%) [other IJD]	338/484,277 (0.07%) [all controls], 245/484,277 (0.11%) [RA controls], 93/484,277 (0.04%) [other IJD controls]	Higher for RA (fully adjusted HR 1.27, 1.02-1.59) Equal for all (fully adjusted HR 1.18, 0.97-1.44), other IJD (0.83, 0.54-1.28) Comparable to increased all-cause mortality risk and not different from 2015-19	
Cleaton[25]	UK	-	1 Feb to 1 May 20	Retrospective	Secondary care	Patients with RMD; followed at outpatient clinic	Physician diagnosis	PCR+	General population in region	10,387	12/10,387 (0.12%)	4,131/7,415,149 (0.12%)	Equal	
Comarmond[14]	France	-	4 May to 20 May 20	Retrospective	Secondary care	Patients with TAK or GCA; followed at outpatient clinic	Physician diagnosis	PCR+ or typical CT imaging or serology+	Modelled risk in country	148	1/8 (12.5%)	2.2% (age 70-79), 8% (age >80)	Lower	

FAI consortium[19]	France	French COVID-19 registry	Until 18 May 20	Retrospective, matched (age, sex, comorbidities)	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	Patients with COVID-19 from the Lille University Hospital COVID-19 Research Network	694	58/256 hospitalised subgroup (22.6%); death rate in matched subgroup (n=175) 25.1% (18.7-31.6)	Death rate 18.9% (13.1-24.7)	Equal (OR 1.45, 0.87-2.42)	
Salvarani[5] (*Susceptibility and*)	Italy	-	Until 24 Apr 20	Retrospective	Secondary care	ts/bDMARD treated RMD patients; treated since Dec 19 (pharmacy data)	Physician diagnosis	PCR+	General population in region	1,195	1/9 (11.1%)	383/3,746 (10.2%)	Equal (p=1.0)	
III.	**Outcome: Other (ICU or 'severe COVID-19')**													
Aries[18]	Germany	Hamburg COVID-19 registry	Until 9 Jun 20	Cross-sectional, registry	Secondary care	DMARD treated RMD patients with COVID-19; cases reported by rheumatologists	Physician diagnosis	Symptoms and PCR+ or IgG+	General population in region	11,771	ICU admission 3/30 (10%)	227/5,120 (4.4%)	Lower	
Bower[15]	Sweden	-	May to Sep 20	Retrospective, registry, matched	Population-based	Inflammatory arthritis patients; data from national registries	Physician diagnosis	ICD-10	General population registries, matched (age, sex, location)	110,567	ICU admission 45/110,567 (0.04%) [all], 31/53,455 (0.06%) [RA], 14/57,112 (0.6%) [other IJD]	162/484,277 (0.01%) [all controls], 79/484,277 (0.02%) [RA controls], 83/484,277 (0.03%) [other IJD controls]	Equal for all (fully adjusted HR 1.18, 0.97-1.44), RA (1.53, 0.98-2.40), other IJD (0.83, 0.54-1.28)	
Cordtz[17]	Denmark	DANBIO	1 Mar to 12 Aug 20	Retrospective, registry	Population-based	ts/bDMARD treated RA, SpA, CTD or vasculitis patients; data from national registries	Physician diagnosis	ICD-10	General population registries	29,440	'severe COVID-19'* 22/47 (age- and sex-adjusted IR per 1000 py 35.2, 20.8-59.4)	945/2,536 (age- and sex-adjusted IR per 1000 py 32.7, 30.7-34.9)	Higher (HR 1.43, 0.80-2.53)	

*'severe COVID-19' was only assessed in RA patients and defined as need for mechanical ventilation (procedure code), ICD-10 code of acute respiratory distress syndrome due to COVID-19 or death following COVID-19. Colours denote overall RoB assessment of each study (green: low risk of bias, orange: unclear risk of bias, red: high risk of bias).

(ts/b)DMARD, (targeted synthetic/biologic) disease-modifying anti-rheumatic drug; CT, computerized tomography; (u)CTD, (undifferentiated) connective tissue disease; GCA, giant cell arteritis; HR, hazard ratio; ICU, intensive care unit; IJD, inflammatory joint disease; IM, inflammatory myopathy; IR, incidence rate; mln, million; MTX, methotrexate; NR, not reported; OR, odds ratio; PCR, polymerase chain reaction; PMR, polymyalgia rheumatica; PsA, psoriatic arthritis, py, person years; RA, rheumatoid arthritis; RMD, rheumatic and musculoskeletal diseases; RoB, risk of bias; SjS, Sjögren syndrome; SLE, systemic lupus erythematosus; SpA, spondyloarthritis; TAK, Takayasu arteritis; UK, United Kingdom.

Risk factors for developing (severe) COVID-19

Demographics

In total, 13 studies investigated the association between a variety of demographic factors and different COVID-19 related outcomes (Supplementary Table 8). Generally, these studies found that evidence for well-known risk factors for developing (severe) COVID-19 in the general population, such as increased age, male gender and high body mass index (BMI), also apply to patients with RMDs. One USA-based study reported that the risk of hospitalisation, COVID-19 related death and 'severe COVID-19' is elevated in people from Afro-American, Latin-American, Asian, or other/mixed race compared to people from White race.[26]

Comorbidities

The risk of various common comorbidities for developing (severe) COVID-19 in patients with RMDs was investigated in 14 studies (Supplementary Table 9). Associations are similar to those known from the general population, such as cardiovascular disease, diabetes mellitus, chronic lung disease and chronic kidney disease.

RMD type

In total, 19 studies assessed the association between type of RMD and the risk of contracting SARS-CoV-2 (n=4), COVID-19 related hospitalisation (n=9), COVID-19 related death (n=7) and 'severe COVID-19' (n=7) (Supplementary Table 10). A wide range of RMD types and comparisons were studied. Most studies were at unclear or high RoB. The majority did not adequately adjust for important confounders, such as antirheumatic medication or disease activity. Overall, no consistent difference in risk between different RMDs was found. Some studies reported a signal for an increased risk of hospitalisation in patients with autoinflammatory diseases or systemic autoimmune diseases, and for developing 'severe COVID-19' in patients with connective tissue disease (CTD), compared to patients with inflammatory arthritis. However, these results were not consistent across all studies that compared these patient groups.

Risk associated with antirheumatic medication and disease activity

A total of 26 studies assessed the association between a variety of antirheumatic medication and the risk of contracting SARS-CoV-2 (n=4), COVID-19 related hospitalisation (n=13), COVID-19 related death (n=9) and 'severe COVID-19' (n=10) (Supplementary Table 11).

Disease activity

Two studies, both from the Global Rheumatology Alliance (GRA)-COVID-19 registry, reported moderate or high disease activity as a risk factor for COVID-19 related death in RMD patients (OR 1.87, 95% CI 1.27-2.77)[27] and for 'severe COVID-19' in patients with systemic lupus erythematosus (SLE) (OR 2.24, 1.46-3.43),[28] even after extensive adjustment including the use of antirheumatic medication.

Non-steroidal anti-inflammatory drugs (NSAIDs)

NSAIDs were not associated with the risk of contracting SARS-CoV-2 (n=2; 1 low RoB),[12,29] COVID-19 related hospitalisation (n=1)[30] or COVID-19 related death (n=2; 1 low RoB).[29,31]

Glucocorticoids

Glucocorticoid use was associated with an increased risk of COVID-19 hospitalisation in seven studies (1 low RoB), although not all analyses reached statistical significance.[17,19,21,30,32-34] Two studies showed that this increased risk was particularly present in those using a daily dosage of 10 mg or more.[30,32] Similar results were found in studies assessing the association between glucocorticoid use and COVID-19 related death (n=2)[27,35] or 'severe COVID-19' (n=5).[19,28,36-38] Again, a dose-response effect was found.[27,28,36] Strangfeld et al. performed subgroup analyses of inflammatory arthritis and CTD/vasculitis patients separately, and reported that the increased risk of COVID-19 related death associated with glucocorticoid use only remained in the CTD/vasculitis subgroup.[27] A post-hoc analysis of the same study, using data from the GRA-COVID-19 registry, strongly suggested that the association with glucocorticoids mainly results from confounding by disease activity.

Conventional synthetic DMARDs (csDMARDs)

Antimalarial drugs were not associated with the risk of contracting SARS-CoV-2 (n=2),[39,40] COVID-19 related death (n=4)[27,41-43] or 'severe COVID-19' (n=3).[36,43,44] Five studies (1 low RoB) also found no association with COVID-19 related hospitalisation,[17,32,41,43,44] though a small study by Haberman et al. reported an increased risk.[34]

Single studies investigated the risk associated with the use of various other csDMARDs, including methotrexate (COVID-19 hospitalisation, no association, n=2),[34,41] sulfasalazine (COVID-19 related death, higher risk (OR 3.6, 95%CI 1.66-7.78), n=1)[27] and leflunomide (COVID-19 related death, no association, n=1).[27]

Biologic and targeted synthetic DMARDs (b/tsDMARDs)

Tumor necrosis factor alpha inhibitors (TNFi) were not associated with COVID-19 related hospitalisation in four studies (2 low RoB),[15,17,21,34] while two studies suggested a "protective" effect.[19,32] TNFi use was not associated with COVID-19 related death (n=2; 1 low RoB)[15,27] or 'severe COVID-19' (n=1, low RoB).[15]

One study suggested that rituximab was associated with an increased risk of contracting SARS-CoV-2,[45] though two other studies (1 low RoB) did not confirm this association.[15,32] Multiple studies found a higher risk of COVID-19 related death (n=4; 1 low RoB)[15,27,35,45] and 'severe COVID-19' (n=4),[19,36,45,46] although not all analyses reached statistical significance. Several of these studies are separate analyses of (parts of) the GRA-COVID-19 registry.

Fewer studies investigated Janus kinase inhibitors (JAKi), of which most found a higher risk of COVID-19 related hospitalisation (n=2; 1 low RoB),[15,34] COVID-19 related death (n=1, low RoB),[15] and 'severe COVID-19' (n=1).[46] Strangfeld et al. reported no association between JAKi use and COVID-19 related death.[27]

Single studies investigated other b/tsDMARDs, including abatacept, belimumab, interleukin-6 inhibitors (IL6i), IL17i and IL23i, but no association was observed with any of the COVID-19 outcomes.

Studies (n=3; 1 low RoB)[15,21,34] found no association with COVID-19 related hospitalisation, COVID-19 related death (n=1, low RoB)[15] or 'severe COVID-19' (n=2; 1 low RoB)[15] for any bDMARD users versus non-b/tsDMARD users.

Immunosuppressive medication

Few studies investigated the risk associated with use of immunosuppressive medication. One study found a higher risk of COVID-19 related death in users of immunosuppressive medication (a heterogeneous group comprised of azathioprine, cyclosporine, cyclophosphamide, mycophenolate or tacrolimus users), compared to methotrexate users (OR 2.22, 95%CI 1.43-3.46).[27] One study also reported a higher risk of 'severe COVID-19' in mycophenolate mofetil users (OR 6.60, 1.47-29.62),[19] while another found no association with this outcome in users of immunosuppressive medication.[36] These studies were all conducted in the GRA-COVID-19 registry.

Vaccination against SARS-CoV-2

In total, 14 articles, two of which were pre-prints, with data on vaccination against SARS-CoV-2 in patients with RMDs were identified (Supplementary Table 12).

Efficacy

Nine out of 14 studies reported on the efficacy of vaccination against SARS-CoV-2, measured as (presence or level of) antibody response (Supplementary Table 12). Four studies had a prospective design, three were cross-sectional and one was retrospective. The studies consisted of patients with (inflammatory) RMDs (n=5) or patients with various chronic inflammatory/autoimmune diseases including RMDs (n=3). Five studies also included a healthy control group. The number of RMD patients ranged from 68[47] to 807[48]. All participants received an mRNA vaccine. Responsiveness was measured after the second dose in most studies (n=6). RoB was high (n=6) or unclear (n=2) in most studies.

The percentage of cases with a detectable antibody response ranged from 62% to 100% (median 88%, n=8 studies), while this was 96% to 100% (median 100%, n=5 studies) in controls. Five studies measured the level of antibody response, all demonstrating lower IgG antibody titres or neutralizing titres in cases versus controls.

One study assessed T-cell response using flow cytometry in a subset of participants, reporting a significant increase in spike-specific B-cells, T-follicular helper cells, activated CD4+ T-cells and HLA-DR+ CD8+ T-cells in cases and controls, though activated CD8+ T-cells and granzyme-B-producing CD8+ T-cells were only induced in RMD patients not using methotrexate and healthy controls.[49]

Factors that were negatively associated with antibody response in more than one study were increased age (3/4 studies), and use of rituximab or anti-CD20 (6/6), mycophenolate (4/4)

and glucocorticoids (3/3). Two studies showed that a longer interval between vaccination and rituximab infusion was associated with a positive antibody response.[48,50] Ruddy et al. detailed that 86% of negative responders on glucocorticoids concurrently used rituximab or mycophenolate.[51] Less convincing results were seen for methotrexate (negative association in 2/5 studies), abatacept (2/3) and JAKi (1/2). Use of anticytokine therapy was not, or even positively, associated with antibody response. Furer et al. (low RoB) found detectable antibodies in 86% of cases versus 100% of controls, lower antibody titers in cases, and a negative association with vaccine responsiveness for increased age, rituximab, mycophenolate, glucocorticoids and abatacept (but not methotrexate or JAKi).[48]

In total, 19/2,989 (0.6%, n=5 studies) RMD patients developed post-vaccination COVID-19.[48,51-54] One study reported a post-vaccination COVID-19 case in a control subject (1/807, 0.1%).[48]

Safety

Ten studies (1 low RoB) reported safety data (Supplementary Table 12). In all but one study, all patients received an mRNA vaccine. Generally, vaccination was well-tolerated. Reported adverse events, though common, were mild and similar in type and severity/seriousness between RMD patients and controls. Most reported were local symptoms, such as pain at injection site, and less frequently systemic symptoms such as fatigue, myalgia and fever.

Three studies found no post-vaccination disease flare of the underlying RMD in 868 RMD patients,[47,48,55] while a report from the EULAR COVAX registry describes a disease flare in 73 out of 1,375 (5%) patients, of whom 17 experienced a severe flare (mean±SD) 5±5 days post-vaccination.[53]

No RMD specific factors (e.g., disease type or medication) were consistently associated with the development of adverse events

Other outcomes

One USA-based, prospective study assessed the association of SARS-CoV-2 infection with development of a disease flare in Latin-American patients with RMDs, reporting an increased risk (OR 4.57, 95%CI 1.2 to 17.4).[9]

One USA-based, retrospective study in the TriNetX database compared outcomes of matched patients with inflammatory RMDs and COVID-19 in the early (January to April 2020) and late (April to July 2020) phases of the pandemic.[56] The study showed that patients with

COVID-19 in the late cohort fared better than those in the early cohort, based on lower risk of COVID-19 related hospitalisation (RR 0.71, 95% 0.67-0.76), ICU admission (0.56, 0.47-0.65), mechanical ventilation (0.39, 0.31-0.49), death (0.48, 0.39-0.60) and 'severe COVID-19' (composite of ICU admission, mechanical ventilation and death; 0.51, 0.45-0.58). Results from several sensitivity analyses were similar. The results of this study are confirmed in studies from the GRA-COVID-19 database, where adjustment for time period was also significant.[28]

Post-hoc data

As this SLR covers a highly dynamic field in which new studies emerge on a weekly basis, particularly regarding vaccination against SARS-CoV-2, during the review process of the manuscript, a partial literature search update was done for vaccination studies only, in order to provide a more up-to-date overview of these data. Importantly, these data were not available for the task force at the time of deciding on the recommendations. We searched PubMed up to 11 October 2021, using previously described search terms (see Supplementary material), with the addition of specific terms for vaccination. The search retrieved 189 new hits, of which 23 were eligible (Supplementary Table 13). Three reports concerned different outcomes and/or follow-up moments of a study already included in the main search,[57-59] and two reports concerned different outcomes and/or follow-up moments of the same study.[60,61] Risk of bias was not assessed for this post-hoc analysis.

Twelve studies, primarily concerning mRNA vaccines, provided efficacy data. Most studies confirmed a lower seroconversion rate or antibody titre in RMD patients.[62-67] One large study by Boekel et al. showed that after double exposure (i.e., first dose after previous SARS-CoV-2 infection, or second dose of a two-dose vaccination scheme), seroconversion rates became similar in cases and controls, except among those treated with anti-CD20 therapies.[62] Seven studies confirmed the negative association between anti-CD20 therapy and antibody response,[57,58,60,62,63,65,68] though studies assessing T-cell response (all based on interferon-γ release assays) showed signs of a present T-cell response, independent of antibody response.[63,68] Other antirheumatic medications reported to be associated with impaired antibody response include methotrexate (3/3 studies), mycophenolate (3/3 studies) and glucocorticoid use (3/6 studies). One study reported lower immunogenicity of the Ad26.COV2.S vaccine (Johnson & Johnson) compared to mRNA vaccines,[57] but other studies did not report differences between vaccine types. It should be noted that such analyses are hampered by low patient numbers. One small study reported a

beneficial effect of withholding mycophenolate in the peri-vaccination period on antibody response, but at the cost of a disease flare in 2/24 patients.[58]

Seventeen studies assessed vaccine safety, but no new safety signals were reported. Nine studies assessed post-vaccination RMD disease flares, which occurred in 0.6-15% of patients, were generally mild to moderate and not leading to treatment changes (except in one study on SLE patients),[69] and resolved quickly.[59,64,66,69-74] Disease flare within 6-12 months prior to vaccination appeared a risk factor for post-vaccination flare.[59,69] Two case studies described characteristics and outcomes of 26 RMD patients with SARS-CoV-2 infection after complete vaccination.[75,76] The most commonly used antirheumatic medication among these patients were glucocorticoids (n=8, 31%), methotrexate (n=6, 23%), rituximab (n=6, 23%), and mycophenolate (n=5, 19%). Three of the four patients who died were on rituximab. We did not find studies investigating the yield of an additional vaccine dose after an initial primary vaccine series in patients with RMD.

DISCUSSION

Current literature provides no evidence that patients with RMDs face more risk of contracting SARS-CoV-2 than individuals without RMDs. While some studies suggest a higher rate of COVID-19 related hospitalisation in patients with RMDs compared to the general population, there is no evidence that patients with RMDs suffer from higher rates of COVID-19 related mortality or ICU admission. This apparent contradiction may be explained by other factors that influence hospitalisation than COVID-19 severity, such as concern of a worse prognosis by the treating physician and consequently a lower threshold for hospital admission. A large Swedish registry study, judged as being at low RoB, provided convincing evidence for this conclusion, by demonstrating that the increased risk of hospitalisation and mortality observed in RMD patients, particularly RA patients, during the COVID-19 pandemic was similar to the increase reported in previous years.[15] Notably, results of a Danish registry study, which seem to point towards a higher incidence of ‘severe COVID-19’ in RA patients, may be explained by the same mechanism as the Swedish study, but this was not investigated by the authors.[17] Still, if true, the impact of the reported risk estimate from that study is not clinically relevant at the population-level.

Several risk factors for developing (severe) COVID-19 in patients with RMDs were assessed in this systematic review. Generally, demographic risk factors (increased age, male gender, high BMI) and comorbidities (cardiovascular disease, diabetes mellitus, chronic lung disease, chronic kidney disease) known to be associated with a worse prognosis of COVID-19 in the general population, are also applicable to patients with RMDs. Few studies investigated the

role of ethnicity, but they found that RMD patients from most non-White ethnicities, compared to individuals from the White race, likely suffer from a worse prognosis. No consistent difference in risk of developing (severe) COVID-19 was found between different RMDs. While single studies reported a worse prognosis in patients with RA compared to non-RA controls as well as in patients with autoinflammatory or systemic autoimmune diseases or CTD patients compared to those with inflammatory arthritis, these results were not consistent across all studies. In addition, adequate adjustment for factors known to affect prognosis, such as RMD medication and disease activity, was rarely assessed. Only few studies assessed disease activity as a risk factor for worse COVID-19 prognosis, but studies that did so, found compelling evidence that moderate or high disease activity is a negative prognostic factor, even after extensive adjustment for RMD medication, including glucocorticoid use. At the start of the pandemic, a potentially negative effect of NSAIDs and a potentially positive effect of antimalarial drugs in COVID-19 was widely discussed, also outside the rheumatology field, but we did not find an increased or decreased risk of developing (severe) COVID-19 related to either type of medication. Similarly, potential positive effects of IL-6i or TNFi were not evident from the literature. On the other hand, current literature provides evidence for concerns regarding a few other drugs. This particularly pertains to rituximab, which use seems to be associated with an increased risk of COVID-19 related complications and death. While glucocorticoid users, in particular those receiving a daily dose above 10 mg of prednisone or equivalent, seem to be at an increased risk of hospitalisation, COVID-19 related complications and death, there is evidence that this may be largely due to confounding by disease activity. Some studies also provide a signal for worse prognosis of COVID-19 in patients on JAKi. However, in many countries these drugs are prescribed in patients who have failed (multiple) other therapies and therefore patients on JAKi generally suffer from more severe disease, providing ample room for confounding-by-indication as an alternative explanation for the observed increased risk, which may be too large to adjust for, even in well-designed observational studies. No other consistent associations between various RMD medication and developing (severe) COVID-19 were found in the current literature.

The first studies assessing efficacy and safety of vaccination against SARS-CoV-2 have been published, with many more expected to come since vaccination in many Western countries has taken flight. Current data show that, in general, SARS-CoV-2 vaccines are immunogenic in patients with RMDs, although the antibody response is lower compared to healthy controls. Still, the reported number of postvaccination COVID-19 cases in patients with RMDs remains low, and no information is available on the severity of these cases. Particularly older patients, as well as rituximab and mycophenolate users, appear to be at

risk of lower antibody response. The (negative) effect of methotrexate on antibody response is uncertain. Patients on anti-cytokine therapy do not seem to exhibit lower antibody responses. Notably, the relation between measured antibody response and immune protection of the vaccines is unknown, and the extent and impact of T-cell response to SARS-CoV-2 vaccination remains unclear, as it was only reported in a subgroup of patients from one study. Adverse event profiles were comparable to the general population regarding the type and severity/seriousness. There was no literature to inform risk-benefit ratios of additional dose after an initial primary vaccine series in (subgroups of) patients with RMDs. None of the studies investigated the usefulness of stopping or postponing (specific) RMD medication in light of vaccination, although two studies showed that in patients in whom a longer period between rituximab infusion and vaccination existed, the antibody response was higher.[48,50]

Since the end of 2019, a large number of publications on COVID-19 have appeared. However, as is often the case, quantity is not necessarily a measure for quality. This becomes clear from the large number of included studies that were not considered eligible for data-extraction after quality assessment, and from the judgement of high RoB among those that passed the quality filter. A critical caveat relevant for (cohort) studies on COVID-19 in patients with RMDs is ‘selection bias’, which even in well-established registries or large cohorts with extensive correction for confounders, can hardly be eliminated and may lead to spurious associations, particularly in studies with voluntary enrollment of COVID-19 cases. Studies at lowest risk of selection bias, and therefore most informative in this context, are population-based studies using, for example, national registries in which all patients from a country are included irrespective of patient characteristics. Examples of such studies are those from Bower et al. and Cordtz et al.[15,17] Another problem in many studies is ‘confounding-by-indication’ stemming from selective testing for SARS-CoV-2, particularly at the beginning of the pandemic, when testing was not yet widely available.

When interpreting the data presented in this review, it is important to take into account that almost all studies were done during the first wave of the pandemic. This has some advantages for data-interpretation, such as the presence of a lower number of different strains and therefore more homogeneous SARS-CoV-2 infection, and less confounding-by-indication by suspected risk factors of which at the time knowledge about their association with prognosis was lacking. However, this was also the time at which for example SARS-CoV-2 testing was not done ubiquitously, introducing bias as discussed above. The association between risk factors discussed above or efficacy of vaccination in different strains of SARS-CoV-2 is unknown. Furthermore, patients included in studies at a later stage of the pandemic appear to have a better prognosis than those included in the beginning, so it

may be true that in general the studies from the first months of the pandemic paint a more negative picture than is currently justifiable.

In conclusion, this SLR presents an overview of currently available literature on risk and prognosis of SARS-CoV-2 infection and vaccination against SARS-CoV-2 in patients with RMDs, and provided evidence to inform the EULAR task force and formulate the July 2021 update of the recommendations for the management of RMDs in the context of SARS-CoV-2.

COMPETING INTERESTS

FK, AN, AA, JWS have nothing to declare. **RL** received honoraria for lecturing and consultation from AbbVie, Amgen, BMS, Celgene, Galapagos, Gilead, Janssen, Eli Lilly, Novartis, Pfizer, UCB and is owner and director of Rheumatology Consultancy BV. **PMM** received consulting/speaker's fees from Abbvie, BMS, Celgene, Eli Lilly, Galapagos, Janssen, MSD, Novartis, Pfizer, Roche and UCB, all unrelated to this manuscript, and is supported by the National Institute for Health Research (NIHR) University College London Hospitals (UCLH) Biomedical Research Centre (BRC). The views expressed are those of the authors and not necessarily those of the (UK) National Health Service (NHS), the NIHR, or the (UK) Department of Health. **VN-C** received research grants/honoraria from AbbVie, Janssen, Lilly, Novartis, Pfizer, and UCB.

CONTRIBUTORSHIP

All authors contributed to and finally approved the current manuscript.

ACKNOWLEDGMENTS

None.

FUNDING

None.

DATA SHARING STATEMENT

Not applicable.

REFERENCES

1. Landewé RB, Machado PM, Kroon F, et al. EULAR provisional recommendations for the management of rheumatic and musculoskeletal diseases in the context of SARS-CoV-2. *Ann Rheum Dis* 2020;79:851-58.
2. Sackett D, Richardson W, Rosenberg W, et al. Evidence-based medicine: how to practice and teach EBM. London: Churchill Livingstone 1997.
3. Wells G, Shea B, O'Connell D, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp, 2013.
4. Downes MJ, Brennan ML, Williams HC, et al. Development of a critical appraisal tool to assess the quality of cross-sectional studies (AXIS). *BMJ Open* 2016;6:e011458.
5. Salvarani C, Bajocchi G, Mancuso P, et al. Susceptibility and severity of COVID-19 in patients treated with bDMARDS and tsDMARDs: a population-based study. *Ann Rheum Dis* 2020;79:986-88.
6. So H, Mak JW, So J, et al. Incidence and clinical course of COVID-19 in patients with rheumatologic diseases: A population-based study. *Semin Arthritis Rheum* 2020;50:885-89.
7. Favalli EG, Agape E, Caporali R. Incidence and Clinical Course of COVID-19 in Patients with Connective Tissue Diseases: A Descriptive Observational Analysis. *J Rheumatol* 2020;47:1296.
8. Pablos JL, Abasolo L, Alvaro-Gracia JM, et al. Prevalence of hospital PCR-confirmed COVID-19 cases in patients with chronic inflammatory and autoimmune rheumatic diseases. *Ann Rheum Dis* 2020;79:1170-73.
9. Fike A, Hartman J, Redmond C, et al. Risk factors for COVID-19 and rheumatic disease flare in a US cohort of Latino patients. *Arthritis rheumatol* 2021;73:1129-34.
10. Quartuccio L, Treppo E, Binutti M, et al. Timing of Rituximab and immunoglobulin level influence the risk of death for COVID-19 in ANCA-associated vasculitis. *Rheumatology (Oxford)* 2021;60:3476–77.
11. Bjornsson AH, Grondal G, Kristjansson M, et al. Prevalence, admission rates and hypoxia due to COVID-19 in patients with rheumatic disorders treated with targeted synthetic or biologic disease modifying antirheumatic drugs or methotrexate: a nationwide study from Iceland. *Ann Rheum Dis* 2021;80:671-2.
12. Blanch-Rubio J, Soldevila-Domenech N, Tio L, et al. Influence of anti-osteoporosis treatments on the incidence of COVID-19 in patients with non-inflammatory rheumatic conditions. *Aging (Albany NY)* 2020;12:19923-37.
13. Michelena X, Borrell H, Lopez-Corbeto M, et al. Incidence of COVID-19 in a cohort of adult and paediatric patients with rheumatic diseases treated with targeted biologic and synthetic disease-modifying anti-rheumatic drugs. *Semin Arthritis Rheum* 2020;50:564-70.
14. Comarmond C, Leclercq M, Leroux G, et al. 2019 Novel Coronavirus Disease (COVID-19) in Patients with Large-Vessels Vasculitis: Single-centre Experience in Paris. *Arthritis & Rheumatology* 2020;72:Supl 10.
15. Bower H, Frisell T, Di Giuseppe D, et al. Impact of the COVID-19 pandemic on morbidity and mortality in patients with inflammatory joint diseases and in the general population: a nationwide Swedish cohort study. *Ann Rheum Dis* 2021;80:1086-93.
16. Ramirez GA, Gerosa M, Beretta L, et al. COVID-19 in systemic lupus erythematosus: Data from a survey on 417 patients. *Semin Arthritis Rheum* 2020;50:1150-57.
17. Cordtz R, Lindhardsen J, Soussi BG, et al. Incidence and severeness of COVID-19 hospitalisation in patients with inflammatory rheumatic disease: a nationwide cohort study from Denmark. *Rheumatology (Oxford)* 2020 Published Online First: 28 Dec 2020. doi: https://dx.doi.org/10.1093/rheumatology/keaa897
18. Aries P, Iking-Konert C. No increased rate of SARS-CoV-2 infection for patients with inflammatory rheumatic diseases compared with the general population in the city of Hamburg (Germany). *Ann Rheum Dis* 2020 Published Online First: 07 Aug 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218400
19. FAI consortium. Severity of COVID-19 and survival in patients with rheumatic and inflammatory diseases: data from the French RMD COVID-19 cohort of 694 patients. *Ann Rheum Dis* 2020;80:527-38.
20. Bachiller-Corral J, Boteanu A, Garcia-Villanueva MJ, et al. Risk of Severe COVID-19 Infection in Patients With Inflammatory Rheumatic Diseases. *J Rheumatol* 2021;15:15.

21. Fernandez-Gutierrez B, Leon L, Madrid A, et al. Hospital admissions in inflammatory rheumatic diseases during the peak of COVID-19 pandemic: incidence and role of disease-modifying agents. *Ther* 2021;13:1759720X20962692.
22. Flood RM, Conway R, Kirby C, et al. Correspondence to: 'Characteristics associated with hospitalisation for COVID-19 in people with rheumatic disease: data from the COVID-19 Global Rheumatology Alliance physician-reported registry' by Gianfrancesco et al. *Ann Rheum Dis* 2020 Published Online First: 19 August 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218733
23. Jovani V, Calabuig I, Peral-Garrido ML, et al. Incidence of severe COVID-19 in a Spanish cohort of 1037 patients with rheumatic diseases treated with biologics and JAK-inhibitors. *Ann Rheum Dis* 2020 Published Online First: 25 Jun 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218152
24. Santos CS, Fernandez XC, Moriano Morales C, et al. Biological agents for rheumatic diseases in the outbreak of COVID-19: friend or foe? *RMD Open* 2021;7:e001439.
25. Cleaton N, Raizada S, Barkham N, et al. COVID-19 prevalence and the impact on quality of life from stringent social distancing in a single large UK rheumatology centre. *Ann Rheum Dis* 2021;80:e93.
26. Gianfrancesco MA, Leykina LA, Izadi Z, et al. Association of Race and Ethnicity With COVID-19 Outcomes in Rheumatic Disease: Data From the COVID-19 Global Rheumatology Alliance Physician Registry. *Arthritis rheumatol* 2021;73:374-80.
27. Strangfeld A, Schafer M, Gianfrancesco MA, et al. Factors associated with COVID-19-related death in people with rheumatic diseases: results from the COVID-19 Global Rheumatology Alliance physician-reported registry. *Ann Rheum Dis* 2021;80:930-42.
28. Ugarte-Gil MF, Alarcon GS, Seet A, et al. OP0286 CHARACTERISTICS ASSOCIATED WITH SEVERE COVID-19 OUTCOMES IN SYSTEMIC LUPUS ERYTHEMATOSUS (SLE): RESULTS FROM THE COVID-19 GLOBAL RHEUMATOLOGY ALLIANCE (COVID-19 GRA). *Ann Rheum Dis* 2021;80:173-75.
29. Chandan JS, Zemedikun DT, Thayakaran R, et al. Non-steroidal anti-inflammatory drugs and susceptibility to COVID-19. *Arthritis rheumatol* 2021;73:731-39.
30. Gianfrancesco M, Hyrich KL, Al-Adely S, et al. Characteristics associated with hospitalisation for COVID-19 in people with rheumatic disease: data from the COVID-19 Global Rheumatology Alliance physician-reported registry. *Ann Rheum Dis* 2020;79:859-66.
31. Wong AY, MacKenna B, Morton CE, et al. Use of non-steroidal anti-inflammatory drugs and risk of death from COVID-19: an OpenSAFELY cohort analysis based on two cohorts. *Ann Rheum Dis* 2021;80:943-51.
32. Boteanu A, García Fernández A, De la Torre N, et al. POS1260 FACTORS ASSOCIATED WITH SEVERE SARS-COV-2 INFECTION IN PATIENTS WITH INFLAMMATORY RHEUMATIC DISEASES IN MADRID: RESULTS FROM REUMA-COVID SORCOM REGISTRY. *Ann Rheum Dis* 2021;80:914.
33. Freites Nuñez DD, Leon L, Mucientes A, et al. Risk factors for hospital admissions related to COVID-19 in patients with autoimmune inflammatory rheumatic diseases. *Ann Rheum Dis* 2020;79:1393-99.
34. Haberman RH, Castillo R, Chen A, et al. COVID-19 in Patients With Inflammatory Arthritis: A Prospective Study on the Effects of Comorbidities and Disease-Modifying Antirheumatic Drugs on Clinical Outcomes. *Arthritis rheumatol* 2020;72:1981-89.
35. Alpizar-Rodriguez D, Irazoque-Palazuelos F, Rodriguez-Reyne TS, et al. POS1242 FACTORS ASSOCIATED WITH MORTALITY IN PATIENTS WITH RHEUMATIC DISEASES AND COVID-19 IN MEXICO. *Ann Rheum Dis* 2021;80:904.
36. Esatoglu SN, Tascilar K, Babaoglu H, et al. COVID-19 Among Patients With Inflammatory Rheumatic Diseases. *Front Immunol* 2021;12:651715.
37. Pablos JL, Galindo M, Carmona L, et al. Clinical outcomes of hospitalised patients with COVID-19 and chronic inflammatory and autoimmune rheumatic diseases: a multicentric matched cohort study. *Ann Rheum Dis* 2020;79:1544-49.
38. Scirè CA, Carrara G, Zanetti A, et al. COVID-19 in rheumatic diseases in Italy: first results from the Italian registry of the Italian Society for Rheumatology (CONTROL-19). *Clin Exp Rheumatol* 2020;38:748-53.
39. Jung SY, Kim MS, Kim MC, et al. Effect of hydroxychloroquine pre-exposure on infection with SARS-CoV-2 in rheumatic disease patients: a population-based cohort study. *Clin Microbiol Infect* 2021;27:611-17.

40. Kim JW, Kwak SG, Lee H, et al. Baseline use of hydroxychloroquine or immunosuppressive drugs and the risk of coronavirus disease 2019. *Korean J Intern Med* 2021 Published Online First: 12 Mar 2021. doi: https://dx.doi.org/10.3904/kjim.2020.633
41. Alegiani SS, Crisafulli S, Rossi PG, et al. Risk of COVID-19 hospitalization and mortality in rheumatic patients treated with hydroxychloroquine or other conventional DMARDs in Italy. *Rheumatology (Oxford)* 2021 Published Online First: 15 Apr 2021. doi: https://dx.doi.org/10.1093/rheumatology/keab348
42. Rentsch CT, DeVito NJ, MacKenna B, et al. Effect of pre-exposure use of hydroxychloroquine on COVID-19 mortality: a population-based cohort study in patients with rheumatoid arthritis or systemic lupus erythematosus using the OpenSAFELY platform. *Lancet Rheumatol* 2021;3:e19-e27.
43. Trefond LDEAMC-CNSRDMDEDYMSELAMIQVRMSJB. Impact of hydroxychloroquine used as DMARD on SARS CoV-2 tests and infection evolution in a population of 871 patients with inflammatory rheumatic and musculoskeletal diseases. *Joint Bone Spine* 2021:105226.
44. Sbidian E, Penso L, Herlemont P, et al. Comment on 'Baseline use of hydroxychloroquine in systemic lupus erythematosus does not preclude SARS-CoV-2 infection and severe COVID-19' by Konig et al. Long-term exposure to hydroxychloroquine or chloroquine and the risk of hospitalisation with COVID-19: a nationwide, observational cohort study in 54 873 exposed individuals and 155 689 matched unexposed individuals in France. *Ann Rheum Dis* 2020 Published Online First: 28 Aug 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218647
45. Avouac J, Drumez E, Hachulla E, et al. COVID-19 outcomes in patients with inflammatory rheumatic and musculoskeletal diseases treated with rituximab: a cohort study. *Lancet Rheumatol* 2021;3:e419-26.
46. Sparks JA, Wallace ZS, Seet AM, et al. Associations of baseline use of biologic or targeted synthetic DMARDs with COVID-19 severity in rheumatoid arthritis: Results from the COVID-19 Global Rheumatology Alliance physician registry. *Ann Rheum Dis* 2021;80:1137-46.
47. Geisen UM, Berner DK, Tran F, et al. Immunogenicity and safety of anti-SARS-CoV-2 mRNA vaccines in patients with chronic inflammatory conditions and immunosuppressive therapy in a monocentric cohort. *Annals of the Rheumatic Diseases* 2021 Published Online First: 24 Mar 2021. doi: http://dx.doi.org/10.1136/annrheumdis-2021-220272
48. Furer V, Eviatar T, Zisman D, et al. Immunogenicity and safety of the BNT162b2 mRNA COVID-19 vaccine in adult patients with autoimmune inflammatory rheumatic diseases and in the general population: a multicentre study. *Ann Rheum Dis* 2021 Published Online First: 14 Jun 2021. doi: 10.1136/annrheumdis-2021-220647
49. Haberman RH, Herati R, Simon D, et al. Methotrexate hampers immunogenicity to BNT162b2 mRNA COVID-19 vaccine in immune-mediated inflammatory disease. *Ann Rheum Dis* 2021 Published Online First: 25 May 2021. doi: 10.1136/annrheumdis-2021-220597
50. Spiera R, Jinich S, Jannat-Khah D. Rituximab, but not other antirheumatic therapies, is associated with impaired serological response to SARS- CoV-2 vaccination in patients with rheumatic diseases. *Ann Rheum Dis* 2021 Published Online First: 11 May 2021. doi: https://dx.doi.org/10.1136/annrheumdis-2021-220604
51. Ruddy JA, Connolly CM, Boyarsky BJ, et al. High antibody response to two-dose SARS-CoV-2 messenger RNA vaccination in patients with rheumatic and musculoskeletal diseases. *Ann Rheum Dis* 2021 Published Online First: 24 May 2021. doi: https://dx.doi.org/10.1136/annrheumdis-2021-220656
52. Connolly CM, Ruddy JA, Boyarsky BJ, et al. Safety of the first dose of mRNA SARS-CoV-2 vaccines in patients with rheumatic and musculoskeletal diseases. *Ann Rheum Dis* 2021;80:1100-01.
53. Machado PM, Lawson-Tovey S, Hyrich K, et al. LB0002 COVID-19 VACCINE SAFETY IN PATIENTS WITH RHEUMATIC AND MUSCULOSKELETAL DISEASE. *Ann Rheum Dis* 2021;80:199-200.
54. Ramirez GA, Della-Torre E, Moroni L, et al. Correspondence on 'Immunogenicity and safety of anti-SARS-CoV-2 mRNA vaccines in patients with chronic inflammatory conditions and immunosuppressive therapy in a monocentric cohort'. *Ann Rheum Dis* 2021 Published Online First: 24 May 2021. doi: 10.1136/annrheumdis-2021-220539
55. Braun-Moscovici Y, Kaplan M, Markovits D, et al. Humoral response to Pfizer mRNA vaccine against SARS CoV2, in patients with autoimmune inflammatory rheumatic diseases and the impact on the rheumatic disease activity. *MedRxiv (pre-print)* 2021 doi: https://doi.org/10.1101/2021.04.02.21254493

56. Jorge A, D'Silva KM, Cohen A, et al. Temporal trends in severe COVID-19 outcomes in patients with rheumatic disease: a cohort study. *Lancet Rheumatol* 2021;3:E131-37.
57. Chiang T, Connolly C, Ruddy J, et al. Antibody response to the Janssen/Johnson & Johnson SARS-CoV-2 vaccine in patients with rheumatic and musculoskeletal diseases. *Ann Rheum Dis* 2021;80:1365-66.
58. Connolly C, Chiang T, Boyarsky B, et al. Temporary hold of mycophenolate augments humoral response to SARS-CoV-2 vaccination in patients with rheumatic and musculoskeletal diseases: a case series. *Ann Rheum Dis* 2021 Published Online First: 23 Sep 2021. doi: 10.1136/annrheumdis-2021-221252
59. Connolly C, Ruddy J, Boyarsky B, et al. Disease Flare and Reactogenicity in Patients with Rheumatic and Musculoskeletal Diseases Following Two-Dose SARS-CoV-2 Messenger RNA Vaccination. *Arthritis rheumatol* 2021 Published Online First: 4 Aug 2021. doi: 10.1002/art.41924
60. Ammitzbøll C, Bartels L, Bøgh Andersen J, et al. Impaired Antibody Response to the BNT162b2 Messenger RNA Coronavirus Disease 2019 Vaccine in Patients With Systemic Lupus Erythematosus and Rheumatoid Arthritis. *ACR Open Rheumatol* 2021;3:622-28.
61. Bartels L, Ammitzbøll C, Andersen J, et al. Local and systemic reactogenicity of COVID-19 vaccine BNT162b2 in patients with systemic lupus erythematosus and rheumatoid arthritis. *Rheumatol Int* 2021;41:1925-31.
62. Boekel L, Steenhuis M, Hooijberg F, et al. Antibody development after COVID-19 vaccination in patients with autoimmune diseases in the Netherlands: a substudy of data from two prospective cohort studies. *Lancet Rheumatology* 2021 Published Online First: 6 Aug 2021. doi: 10.1016/S2665-9913(21)00222-8
63. Bonelli M, Mrak D, Perkmann T, et al. SARS-CoV-2 vaccination in rituximab-treated patients: evidence for impaired humoral but inducible cellular immune response. *Ann Rheum Dis* 2021;80:1355-56.
64. Izmirly P, Kim M, Samanovic M, et al. Evaluation of Immune Response and Disease Status in SLE Patients Following SARS-CoV-2 Vaccination. *Arthritis rheumatol* 2021 Published Online First: 4 Aug 2021. doi: 10.1002/art.41937
65. Medeiros-Ribeiro A, Aikawa N, Saad C, et al. Immunogenicity and safety of the CoronaVac inactivated vaccine in patients with autoimmune rheumatic diseases: a phase 4 trial. *Nat Med* 2021 Published Online First: 30 Jul 2021. doi: 10.1038/s41591-021-01469-5
66. Picchianti-Diamanti A, Aiello A, Laganà B, et al. Immunosuppressive Therapies Differently Modulate Humoral- and T-Cell- Specific Responses to COVID-19 mRNA Vaccine in Rheumatoid Arthritis Patients. *Front Immunol* 2021;12:740249.
67. Rubbert-Roth A, Vuilleumier N, Ludewig B, et al. Anti-SARS-CoV-2 mRNA vaccine in patients with rheumatoid arthritis. *Lancet Rheumatol* 2021;3:e470-72.
68. Benucci M, Damiani A, Infantino M, et al. Presence of specific T cell response after SARS-CoV-2 vaccination in rheumatoid arthritis patients receiving rituximab. *Immunol Res* 2021;69:309-11.
69. Felten R, Kawka L, Dubois M, et al. Tolerance of COVID-19 vaccination in patients with systemic lupus erythematosus: the international VACOLUP study. *Lancet Rheumatol* 2021;3
70. Barbhaiya M, Levine J, Bykerk V, et al. Systemic rheumatic disease flares after SARS-CoV-2 vaccination among rheumatology outpatients in New York City. *Ann Rheum Dis* 2021;80:1352-54.
71. Bixio R, Bertelle D, Masia M, et al. Incidence of Disease Flare After BNT162b2 Coronavirus Disease 2019 Vaccination in Patients With Rheumatoid Arthritis in Remission. *ACR Open Rheumatol* 2021 Published Online First: 2 Sep 2021. doi: 10.1002/acr2.11336
72. Moyon Q, Sterlin D, Miyara M, et al. BNT162b2 vaccine-induced humoral and cellular responses against SARS-CoV-2 variants in systemic lupus erythematosus. *Ann Rheum Dis* 2021 Published Online First: 4 Oct 2021. doi: 10.1136/annrheumdis-2021-221097
73. Rotondo C, Cantatore F, Fornaro M, et al. Preliminary Data on Post Market Safety Profiles of COVID 19 Vaccines in Rheumatic Diseases: Assessments on Various Vaccines in Use, Different Rheumatic Disease Subtypes, and Immunosuppressive Therapies: A Two-Centers Study. *Vaccines (Basel)* 2021;9:730.
74. Sattui S, Liew J, Kennedy K, et al. Early experience of COVID-19 vaccination in adults with systemic rheumatic diseases: results from the COVID-19 Global Rheumatology Alliance Vaccine Survey. *RMD Open* 2021;7:e001814.
75. Cook C, Patel N, D'Silva K, et al. Clinical characteristics and outcomes of COVID-19 breakthrough infections among vaccinated patients with systemic autoimmune rheumatic diseases. *Ann Rheum Dis* 2021 Published Online First: 6 Sep 2021. doi: 10.1136/annrheumdis-2021-221326

76. Lawson-Tovey S, Hyrich K, Gossec L, et al. SARS-CoV-2 infection after vaccination in patients with inflammatory rheumatic and musculoskeletal diseases. *Ann Rheum Dis* 2021 Published Online First: 6 Sep 2021. doi: 10.1136/annrheumdis-2021-221217

Risk and prognosis of SARS-CoV-2 infection and vaccination against SARS-CoV-2 in rheumatic and musculoskeletal diseases: a systematic literature review to inform EULAR recommendations

Online Supplementary Material

Table of content

Research questions and PICO tables

(1) Do patients with RMDs face more risk of contracting SARS-CoV-2?
P Patients with RMDs
I Exposure to SARS-CoV-2
C General population
O Including, but not limited to: Risk of SARS-CoV-2 infection, risk of COVID-19

(2) Do patients with RMDs have a worse prognosis when contracting SARS-CoV-2?
P Patients with RMDs
I Exposure to SARS-CoV-2
C General population
O Including, but not limited to: Prognosis, viral clearance, hospitalisation, ICU admission, non-invasive ventilation, invasive ventilation, mortality, combined/composite severity outcomes

(3) In patients with RMDs who contract SARS-CoV-2, is antirheumatic medication associated with a worse outcome?
P Patients with RMDs and SARS-CoV-2 infection
I Antirheumatic medication, including: NSAIDs, glucocorticoids, csDMARDs, tsDMARDs, bDMARDs, immunoglobulins, osteoporosis medication, colchicine, analgesics, opioids
C Not treated with the respective medication
O Including, but not limited to: Prognosis, viral clearance, hospitalisation, ICU admission, non-invasive ventilation, invasive ventilation, mortality, combined/composite severity outcomes

(4) Should patients with RMDs who contract SARS-CoV-2 continue their drug treatment?
P Patients with RMDs and SARS-CoV-2 infection
I Antirheumatic medication, including: NSAIDs, glucocorticoids, csDMARDs, tsDMARDs, bDMARDs, immunoglobulins, osteoporosis medication, colchicine, analgesics, opioids
C Stopping or decreasing (dosage of) drug treatment
O Including, but not limited to: Prognosis, viral clearance, hospitalisation, ICU admission, non-invasive ventilation, invasive ventilation, mortality, combined/composite severity outcomes, disease flares

(5) What evidence informs the use of vaccination against SARS-CoV-2 in patients with RMDs?
P Patients with RMDs
I SARS-CoV-2 vaccination (including all types of vaccines)
C General population
O Including, but not limited to: Efficacy, safety, disease flares

Search strategy

MEDLINE via OVID

((exp Musculoskeletal Diseases/ OR (musculoskeletal adj2 (disease* or disorder*)).mp. OR exp Osteoarthritis/ OR (degenerative adj2 arthritis).mp OR osteoarthritis.mp OR exp Connective Tissue Diseases/ OR (connective adj tissue adj2 (disease* or disorder*)).mp OR Rheumatic Diseases/ OR (rheumatic adj2 (disease* or disorder*)).mp OR exp Lupus Erythematosus, Systemic/ OR lupus.mp OR exp Antiphospholipid Syndrome/ OR antiphospholipid.mp OR Sjogren's Syndrome/ OR (sjogren* or sjoegren*).mp OR exp Scleroderma, Systemic/ OR "systemic sclerosis".mp OR scleroderma.mp OR Scleroderma, Localized/ OR exp Arthritis, Rheumatoid/ OR (rheumatoid adj2 arthritis).mp OR Arthritis, Psoriatic/ OR (psoriatic adj2 arthritis).mp OR (psoriatic adj2 arthropathy).mp OR Spondylitis, Ankylosing/ OR (ankylosing adj2 spondylitis).mp OR (scleroderma adj2 (localised or localized)).mp OR Arthritis, Juvenile/ OR (juvenile adj2 arthritis).mp OR exp Polymyositis/ OR polymyositis.mp OR Dermatomyositis/ OR dermatomyositis.mp OR dermatomyositides.mp OR exp Spondylarthritis/ OR (Spondyloarthritis or spondylarthritis or spondarthritis or (spinal adj2 arthritis)).mp OR Fibromyalgia/ OR fibromyalgia.mp OR Gout/ OR gout.mp OR exp Chondrocalcinosis/ OR chondrocalcinosis.mp OR (calcium adj pyrophosphate adj2 disease*).mp OR (calcium adj pyrophosphate adj2 deposition).mp OR pseudogout.mp OR exp Vasculitis/ OR vasculitis.mp OR Angiitis.mp OR Angiitides.mp OR angitis.mp OR (vascular adj2 inflammation).mp OR (vasculitic adj2 lesion*).mp OR Angioitis.mp OR exp Sarcoidosis/ OR Sarcoid.mp OR Sarcoidosis.mp OR ("Besnier Boeck" adj2 (disease or syndrome)).mp OR ("Besnier Boeck Schaumann" adj2 (disease or syndrome)).mp OR Sarcoidoses.mp OR "Polymyalgia Rheumatica"/ OR "polymyalgia rheumatica".mp OR "Giant Cell Arteritis"/ OR "giant cell arteritis".mp) AND (exp Coronavirus/ OR exp Coronavirus Infections/ OR ("2019-nCoV*" or 2019nCoV* or "19-nCoV*" or 19nCoV* or nCoV2019* or "nCoV-2019*" or nCoV19* or "nCoV-19*" or "COVID-19*" or COVID19* or "COVID-2019*" or COVID2019* or "HCoV-19*" or HCoV19* or "HCoV-2019*" or HCoV2019* or "2019 novel*" or Ncov* or "n-cov" or "SARS-CoV-2*" or "SARSCoV-2*" or "SARSCoV2*" or "SARS-CoV2*" or SARSCov19* or "SARS-Cov19*" or "SARSCov-19*" or "SARS-Cov-19*" or SARSCov2019* or "SARS-Cov2019*" or "SARSCov-2019*" or "SARS-Cov-2019*" or SARS2* or "SARS-2*" or SARScoronavirus2* or "SARS-coronavirus-2*" or "SARScoronavirus 2*" or "SARS coronavirus2*" or SARScoronovirus2* or "SARS-coronovirus-2*" or "SARScoronovirus 2*" or "SARS coronovirus2*" or covid).ti,ab,kw,kf OR "severe acute respiratory syndrome*".ti,ab,kw,kf OR ((corona* or corono*) adj1 (virus* or viral* or virinae*)).ti,ab,kw,kf OR (coronavirus* or coronovirus* or coronavirinae* or CoV).ti,ab,kw,kf) AND (2019 OR 2020 OR 2021 OR 2022).yr)

Embase

((exp *musculoskeletal disease/ OR (musculoskeletal adj2 (disease* or disorder*)).ti,ab OR exp *osteoarthritis/ OR osteoarthritis.ti,ab OR (degenerative adj2 arthritis).ti,ab OR exp *connective tissue disease/ OR (connective adj tissue adj2 (disease* or disorder*)).ti,ab OR exp *rheumatic disease/ OR (rheumatic adj2 (disease* or disorder*)).ti,ab OR exp *systemic lupus erythematosus/ OR lupus.ti,ab OR *antiphospholipid syndrome/ OR antiphospholipid.ti,ab OR *Sjoegren syndrome/ OR (sjogren* or sjoegren*).ti,ab OR exp *systemic sclerosis/ OR "systemic sclerosis".ti,ab OR scleroderma.ti,ab OR exp *localized scleroderma/ OR exp *rheumatoid arthritis/ OR (rheumatoid adj2 arthritis).ti,ab OR *psoriatic arthritis/ OR (psoriatic adj2 arthritis).ti,ab OR (psoriatic adj2 arthropathy).ti,ab OR *ankylosing spondylitis/ OR (ankylosing adj2 spondylitis).ti,ab OR (scleroderma adj2 (localised or localized)).ti,ab OR exp *juvenile rheumatoid arthritis/ OR (juvenile adj2 arthritis).ti,ab OR *polymyositis/ OR polymyositis.ti,ab OR exp *dermatomyositis/ OR dermatomyositis.ti,ab OR dermatomyositides.ti,ab OR *spondylarthritis/ OR spondylarthritis.ti,ab OR *fibromyalgia/ OR fibromyalgia.ti,ab OR gout/ OR gout.ti,ab OR *chondrocalcinosis/ OR chondrocalcinosis.ti,ab

OR (calcium adj pyrophosphate adj2 disease*).ti,ab OR (calcium adj pyrophosphate adj2 deposition).ti,ab OR pseudogout.ti,ab OR exp *vasculitis/ OR vasculitis.ti,ab OR Angiitis.ti,ab OR Angiitides.ti,ab OR angitis.ti,ab OR (vascular adj2 inflammation).ti,ab OR (vasculitic adj2 lesion*).ti,ab OR Angioitis.ti,ab OR exp *sarcoidosis/ OR Sarcoid.ti,ab OR Sarcoidosis.ti,ab OR ("Besnier Boeck" adj2 (disease or syndrome)).ti,ab OR ("Besnier Boeck Schaumann" adj2 (disease or syndrome)).ti,ab OR Sarcoidoses.ti,ab OR *"rheumatic polymyalgia"/ OR "polymyalgia rheumatica".ti,ab OR *"Giant Cell Arteritis"/ OR "giant cell arteritis".ti,ab) AND (exp *Coronavirinae/ OR exp *Coronavirus infection/ OR ("coronavirus disease 2019" or "severe acute respiratory syndrome coronavirus 2").sh,dj. OR ((corona* or corono*) adj1 (virus* or viral* or virinae*)).ti,ab OR ("2019-nCoV*" or 2019nCoV* or "19-nCoV*" or 19nCoV* or nCoV2019* or "nCoV-2019*" or nCoV19* or "nCoV-19*" or "COVID-19*" or COVID19* or "COVID-2019*" or COVID2019* or "HCoV-19*" or HCoV19* or "HCoV-2019*" or HCoV2019* or "2019 novel*" or Ncov* or "n-cov" or "SARS-CoV-2*" or "SARSCoV-2*" or "SARSCoV2*" or "SARS-CoV2*" or SARSCov19* or "SARS-Cov19*" or "SARSCov-19*" or "SARS-Cov-19*" or SARSCov2019* or "SARS-Cov2019*" or "SARSCov-2019*" or "SARS-Cov-2019*" or SARS2* or "SARS-2*" or SARScoronavirus2* or "SARS-coronavirus-2*" or "SARScoronavirus 2*" or "SARS coronavirus2*" or SARScoronovirus2* or "SARS-coronovirus-2*" or "SARScoronovirus 2*" or "SARS coronovirus2*" or covid).ti,ab OR "severe acute respiratory syndrome*".ti,ab OR (coronavirus* or coronovirus* or coronavirinae* or CoV).ti,ab) AND (2019 OR 2020 OR 2021 OR 2022).yr NOT (conference review).pt)

Cochrane
#1 MeSH descriptor: [Musculoskeletal Diseases] explode all trees
#2 MeSH descriptor: [Osteoarthritis] explode all trees
#3 MeSH descriptor: [Connective Tissue Diseases] explode all trees
#4 MeSH descriptor: [Rheumatic Diseases] explode all trees
#5 MeSH descriptor: [Lupus Erythematosus, Systemic] explode all trees
#6 MeSH descriptor: [Antiphospholipid Syndrome] explode all trees
#7 MeSH descriptor: [Sjogren's Syndrome] explode all trees
#8 MeSH descriptor: [Scleroderma, Systemic] explode all trees
#9 MeSH descriptor: [Scleroderma, Localized] explode all trees
#10 MeSH descriptor: [Arthritis, Rheumatoid] explode all trees
#11 MeSH descriptor: [Arthritis, Psoriatic] explode all trees
#12 MeSH descriptor: [Spondylitis, Ankylosing] explode all trees
#13 MeSH descriptor: [Arthritis, Juvenile] explode all trees
#14 MeSH descriptor: [Polymyositis] explode all trees
#15 MeSH descriptor: [Dermatomyositis] explode all trees
#16 MeSH descriptor: [Spondylarthritis] explode all trees
#17 MeSH descriptor: [Fibromyalgia] explode all trees
#18 MeSH descriptor: [Gout] explode all trees
#19 MeSH descriptor: [Chondrocalcinosis] explode all trees
#20 MeSH descriptor: [Vasculitis] explode all trees
#21 MeSH descriptor: [Sarcoidosis] explode all trees
#22 MeSH descriptor: [polymyalgia rheumatica] explode all trees
#23 MeSH descriptor: [Giant Cell Arteritis] explode all trees
#24 ((musculoskeletal near/2 (disease* or disorder*)):ti,ab,kw OR (Osteoarthritis):ti,ab,kw OR (degenerative near/2 arthritis):ti,ab,kw OR ("connective tissue" near/2 disease*):ti,ab,kw OR ("connective tissue" near/2 disorder*):ti,ab,kw OR (rheumatic near/2 (disease* or disorder*)):ti,ab,kw OR (lupus):ti,ab,kw OR (antiphospholipid):ti,ab,kw OR (sjogren* or Sjoegren*):ti,ab,kw OR ("systemic sclerosis"):ti,ab,kw OR (scleroderma):ti,ab,kw OR (rheumatoid near/2 arthritis):ti,ab,kw OR (psoriatic near/2 arthritis):ti,ab,kw OR psoriatic near/2 arthropathy OR (ankylosing near/2 spondylitis):ti,ab,kw OR (scleroderma near/2 (localised or localized)):ti,ab,kw OR (juvenile near/2 arthritis):ti,ab,kw OR (polymyositis):ti,ab,kw OR (dermatomyositis):ti,ab,kw OR (dermatomyositides):ti,ab,kw OR (Spondyloarthritis or spondylarthritis or spondarthritis or (spinal near/2 arthritis)):ti,ab,kw OR

(fibromyalgia):ti,ab,kw OR (gout):ti,ab,kw OR (chondrocalcinosis):ti,ab,kw OR ("calcium pyrophosphate" near/2 disease*):ti,ab,kw OR ("calcium pyrophosphate" near/2 deposition):ti,ab,kw OR (pseudogout):ti,ab,kw OR (vasculitis):ti,ab,kw OR (Angiitis):ti,ab,kw OR (Angiitides):ti,ab,kw OR (angitis):ti,ab,kw OR (vascular near/2 inflammation):ti,ab,kw OR (vasculitic near/2 lesion*):ti,ab,kw OR (Angioitis):ti,ab,kw OR (Sarcoid):ti,ab,kw OR (Sarcoidosis):ti,ab,kw OR ("Besnier Boeck" near/2 (disease or syndrome)):ti,ab,kw OR ("Besnier Boeck Schaumann" near/2 (disease or syndrome)):ti,ab,kw OR (Sarcoidoses):ti,ab,kw OR "polymyalgia rheumatica":ti,ab,kw OR "giant cell arteritis":ti,ab,kw)

#25 or #1-#24

#26 MeSH descriptor: [Coronavirus] explode all trees
#27 MeSH descriptor: [Coronavirus Infections] explode all trees

#28 (((corona* or corono*) near/1 (virus* or viral* or virinae*)):ti,ab,kw OR ((coronavirus* or coronovirus* or coronavirinae* or CoV)):ti,ab,kw OR (("2019 nCoV" or 2019nCoV* or "19 nCoV" or 19nCoV* or nCoV2019* or "nCoV 2019" or nCoV19* or "nCoV 19" or "COVID 19" or COVID19* or "COVID 2019" or COVID2019* or "HCoV 19" or HCoV19* or "HCoV 2019" or HCoV2019* or "2019 novel" or Ncov* or "n cov" or "SARS CoV 2" or "SARSCoV 2" or "SARSCoV2" or "SARS CoV2" or SARSCov19* or "SARS Cov19" or "SARSCov 19" or "SARS Cov 19" or SARSCov2019* or "SARS Cov2019" or "SARSCov 2019" or "SARS Cov 2019" or SARS2* or "SARS 2" or SARScoronavirus2* or "SARS coronavirus 2" or "SARScoronavirus 2" or "SARS coronavirus2" or SARScoronovirus2* or "SARS coronovirus 2" or "SARScoronovirus 2" or "SARS coronovirus2" or covid)):ti,ab,kw OR ("severe acute respiratory syndrome" or "severe acute respiratory syndromes"))

#29 or #26-#28

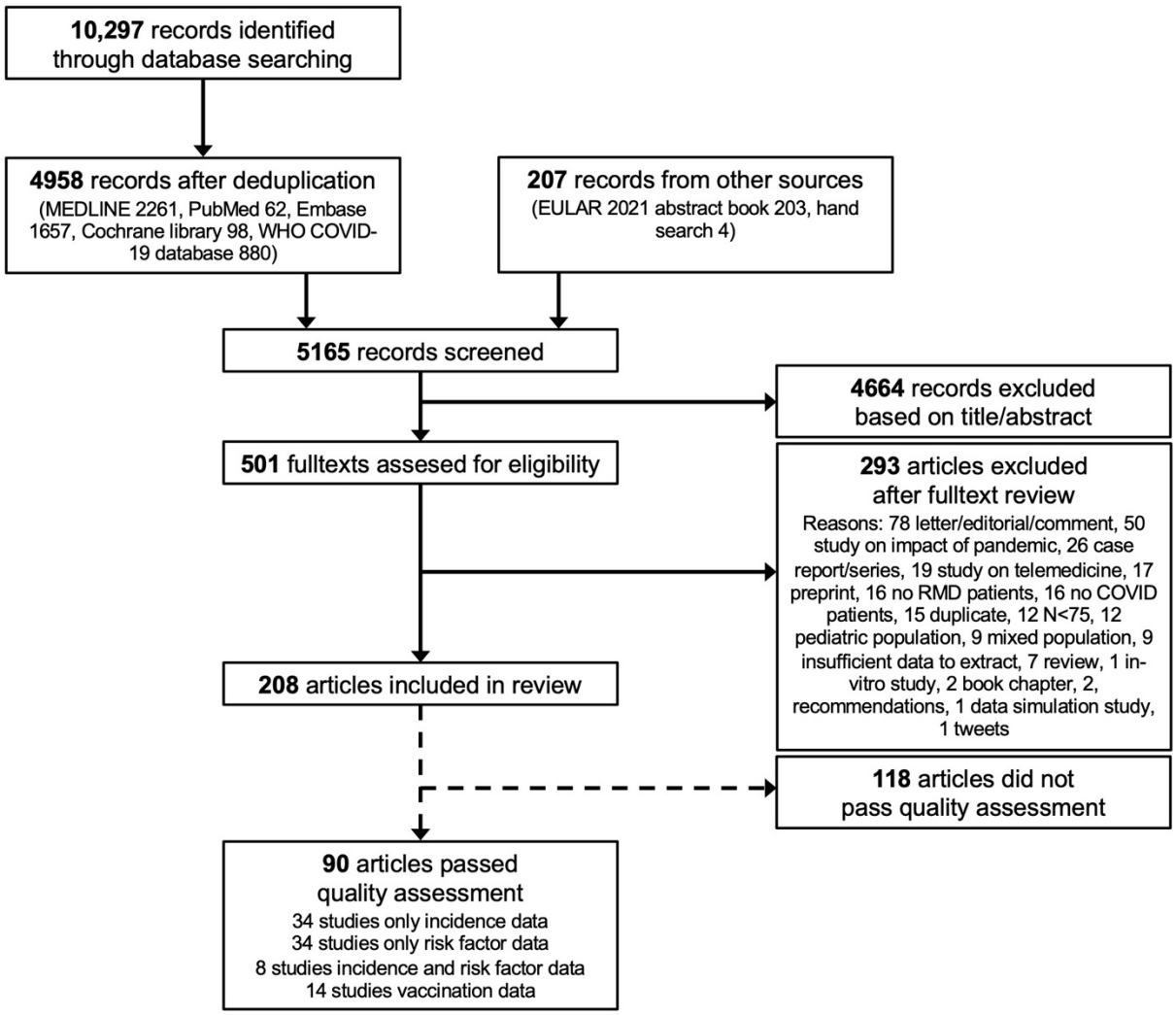
#30 #25 AND #29

WHO Covid-19 database
("Musculoskeletal Diseases" OR "musculoskeletal disease" OR "musculoskeletal disorder" OR "musculoskeletal diseases" OR "musculoskeletal disorders" OR Osteoarthritis OR "degenerative arthritis" OR osteoarthritis OR "Connective Tissue Diseases" OR "connective tissue disease" OR "connective tissue disorder" OR "connective tissue disorders" OR "Rheumatic Diseases" OR "rheumatic disease" OR "rheumatic disorder" OR "rheumatic disorders" OR "Systemic Lupus Erythematosus" OR lupus OR "Antiphospholipid Syndrome" OR "antiphospholipid" OR "Sjogren's Syndrome" OR "sjogren syndrome" OR "sjoegren's syndrome" OR "sjoegren syndrome" OR "systemic sclerosis" OR "scleroderma" OR "rheumatoid arthritis" OR "psoriatic arthritis" OR "psoriatic arthropathy" OR "psoriatic arthropathies" OR "ankylosing spondylitis" OR "juvenile arthritis" OR Polymyositis OR Dermatomyositis OR Spondylarthritis OR Spondyloarthritis OR spondarthritis OR "spinal arthritis" OR Fibromyalgia OR Gout OR Chondrocalcinosis OR "calcium pyrophosphate disease" OR "calcium pyrophosphate deposition" OR pseudogout OR Vasculitis OR Angiitis OR angitis OR "vascular inflammation" OR "vasculitic lesion" OR "vasculitic lesions" OR Angioitis OR Sarcoidosis OR Sarcoid OR "Besnier Boeck" OR Sarcoidoses OR "Polymyalgia Rheumatica" OR "giant cell arteritis")

PubMed
(("Musculoskeletal Diseases"[mesh] OR "musculoskeletal disease*"[tw] OR "musculoskeletal disorder*"[tw] OR Osteoarthritis[mesh] OR "degenerative arthritis"[tw] OR osteoarthritis[tw] OR Connective Tissue Diseases[mesh] OR "connective tissue disease*"[tw] OR "connective tissue disorder*"[tw] OR "Rheumatic Diseases"[mesh] OR "rheumatic disease*"[tw] OR "rheumatic disorder*"[tw] OR "Lupus Erythematosus, Systemic"[mesh] OR lupus[tw] OR Antiphospholipid Syndrome[mesh] OR antiphospholipid[tw] OR "Sjogren's Syndrome"[mesh]

OR sjogren*[tw] OR sjoegren*[tw] OR "Scleroderma, Systemic"[mesh] OR "systemic sclerosis"[tw] OR scleroderma[tw] OR "Scleroderma, Localized"[mesh] OR "Arthritis, Rheumatoid"[mesh] OR "rheumatoid arthritis"[tw] OR Arthritis, Psoriatic[mesh] OR "psoriatic arthritis"[tw] OR "psoriatic arthropath*"[tw] OR Spondylitis, Ankylosing[mesh] OR "ankylosing spondylitis"[tw] OR "localised scleroderma"[tw] OR "localized scleroderma"[tw] OR Arthritis, Juvenile[mesh] OR "juvenile arthritis"[tw] OR Polymyositis[mesh] OR polymyositis[tw] OR Dermatomyositis[mesh] OR dermatomyositis[tw] OR dermatomyositides[tw] OR Spondylarthritis[mesh] OR Spondyloarthritis[tw] OR spondylarthritis[tw] OR spondarthritis[tw] OR "spinal arthritis"[tw] OR Fibromyalgia[mesh] OR fibromyalgia[tw] OR Gout[mesh] OR gout[tw] OR Chondrocalcinosis[mesh] OR chondrocalcinosis[tw] OR "calcium pyrophosphate disease*"[tw] OR "calcium pyrophosphate deposition"[tw] OR pseudogout[tw] OR Vasculitis[mesh] OR vasculitis[tw] OR Angiitis[tw] OR Angiitides[tw] OR angitis[tw] OR "vascular inflammation"[tw] OR "vasculitic lesion*"[tw] OR Angioitis[tw] OR Sarcoidosis[mesh] OR Sarcoid[tw] OR Sarcoidosis[tw] OR "Besnier Boeck"[tw] OR Sarcoidoses[tw] OR "Polymyalgia Rheumatica"[mesh] OR "polymyalgia rheumatica"[tw] OR "Giant Cell Arteritis"[mesh] OR "giant cell arteritis"[tw]) AND (Coronavirus[mesh] OR Coronavirus Infections[mesh] OR "2019-nCoV*"[tw] OR 2019nCoV*[tw] OR "19-nCoV*"[tw] OR 19nCoV*[tw] OR nCoV2019*[tw] OR "nCoV-2019*"[tw] OR nCoV19*[tw] OR "nCoV-19*"[tw] OR "COVID-19*"[tw] OR COVID19*[tw] OR "COVID-2019*"[tw] OR COVID2019*[tw] OR "HCoV-19*"[tw] OR HCoV19*[tw] OR "HCoV-2019*"[tw] OR HCoV2019*[tw] OR "2019 novel*"[tw] OR Ncov*[tw] OR "n-cov"[tw] OR "SARS-CoV-2*"[tw] OR "SARSCoV-2*"[tw] OR "SARSCoV2*"[tw] OR "SARS-CoV2*"[tw] OR SARSCov19*[tw] OR "SARS-Cov19*"[tw] OR "SARSCov-19*"[tw] OR "SARS-Cov-19*"[tw] OR SARSCov2019*[tw] OR "SARS-Cov2019*"[tw] OR "SARSCov-2019*"[tw] OR "SARS-Cov-2019*"[tw] OR SARS2*[tw] OR "SARS-2*"[tw] OR SARScoronavirus2*[tw] OR "SARS-coronavirus-2*"[tw] OR "SARScoronavirus 2*"[tw] OR "SARS coronavirus2*"[tw] OR SARScoronovirus2*[tw] OR "SARS-coronovirus-2*"[tw] OR "SARScoronovirus 2*"[tw] OR "SARS coronovirus2*"[tw] OR covid[tw] OR "severe acute respiratory syndrome*"[tw] OR ((corona*[tw] OR corono*[tw]) AND (virus*[tw] OR viral*[tw] OR virinae*[tw])) OR coronavirus*[tw] OR coronovirus*[tw] OR coronavirinae*[tw] OR CoV[tw]) AND ("2019/01/01"[PDAT] : "3000/12/31"[PDAT]))

Supplementary Figure S1: Flowchart



Supplementary Tables 1 and 2: Overview of studies that did not pass quality assessment

Supplementary Table 1. Studies not eligible for data-extraction based on quality assessment (n=118).							
First author	**Journal**	**Publication type**	**Country**	**Study population**	**Total (N)**	**Confirmed COVID (N)**	**Comment**
Abdellaoui		Abstract (APLAR)	Algeria	IRMD patients	126	1	No base incidence Less than 10 participants with outcome No comparison
Abualfadi	Rheumatol Int	Full report	Egypt	RA patients	1,037	26	No base incidence No comparison
Aliyeva (*POS1259*)		Abstract (EULAR)	Turkey	FMF patients	106	7	No base incidence Less than 10 participants with outcome No comparison
Andreica	Ann Rheum Dis	Correspondence	Germany	IRMD patients	917	3	No base incidence Less than 10 participants with outcome No comparison
Asif (*POS1167*)		Abstract (EULAR)	UK	IRMD patients	287	11	No base incidence No comparison
Antovic (*POS1230*)		Abstract (EULAR)	Sweden	ANCA-associated vasculitis patients	233	20	No base incidence Risk estimates not (fully) adjusted
Banerjee	ACR Open Rheumatol	Full report	US and Canada	Vasculitis patients	662	7	No base incidence Less than 10 participants with outcome No comparison
Barbhaiya		Abstract (ACR)	US	RMD patients	7,057	430 suspected/ confirmed	No base incidence No comparison
Baughman	Sarcoidosis Vasc Diffuse Lung Dis	Full report	Worldwide	Sarcoidosis patients	5,200	116	No base incidence Risk estimates not (fully) adjusted
Beketova	Nauchno-Prakticheskaya Revmatologiya	Full report	Russia	Rituximab treated ANCA-associated vasculitis patients	128	22	No base incidence No comparison
Bellan	Scand J Rheumatol	Letter	Italy	SSc patients	164	1	No base incidence Less than 10 participants with outcome No comparison
Briones-Figueroa		Abstract (ACR)	Spain	SLE patients	251	33	No base incidence Risk estimates not (fully) adjusted
Cacciapaglia	Ann Rheum Dis	Correspondence	Italy	RA patients	1,471	6	Base incidence only indicated as “similar” No comparison
Carubbi	Front Med	Full report	Italy	Primary Sjögren patients	102	2	No base incidence Less than 10 participants with outcome No comparison
Cheila		Abstract	UK	Patients hospitalised with COVID-19	613	613	No base incidence No comparison
Chen (*The plight*)	J Rheumatol	Letter	China	Lupus nefritis patients	101	2	No base incidence Less than 10 participants with outcome No comparison
Cho	Int J Rheum Dis	Correspondence	Asia/Pacific	SLE patients	3,375	3	No base incidence Less than 10 participants with outcome

							No comparison
Conticini	Ann Rheum Dis	Correspondence	Italy	b/tsDMARD treated RMD patients	859	2	No base incidence Less than 10 participants with outcome No comparison
Conway (*POS1162*)		Abstract (EULAR)	Ireland	RMD patients with COVID-19	105	105	No base incidence Insufficient information on adjustments
Costantino	Joint Bone Spine	Full report	France	RA, PsA and SpA patients	655	12	No base incidence Risk estimates not (fully) adjusted 'suspected' COVID-cases included in analysis
Dadalova (*AB0712*)		Abstract (EULAR)	Russia	bDMARD treated RMD patients with COVID-19	95	95	No base incidence No comparison
Del Papa	Ther Adv Musculoskel	Full report	Italy	SSc patients	526	2	No base incidence Less than 10 participants with outcome No comparison
Desbois		Abstract (ACR)	France	Sarcoidosis patients	199	7	No base incidence Less than 10 participants with outcome No comparison
Domsic		Abstract (ACR)	US	SSc patients	385	4	No base incidence Less than 10 participants with outcome No comparison
Espinosa	Ann Rheum Dis	Correspondence	Spain	Behçet patients with COVID-19	2,135	4	No base incidence Less than 10 participants with outcome No comparison
Fasano	Clin Exp Rheumatol	Letter	Italy	SLE patients	268	0	No base incidence Less than 10 participants with outcome No comparison
Fasano (*POS1210*)		Abstract (EULAR)	Italy	RMD patients	1,370	32	No base incidence No comparison
Favalli (*Impact of*)	Arthritis Res Ther	Full report	Italy	RA, UA, PsA and SpA patients	2,050	23	No base incidence Risk estimates not (fully) adjusted
Favalli (*Role of*)	Ann Rheum Dis	Correspondence	Italy	RMD patients	914	6	No base incidence Less than 10 participants with outcome
Favalli (*What is the*)	Ann Rheum Dis	Correspondence	Italy	bDMARD treated RMD patients	530	3	No base incidence Less than 10 participants with outcome No comparison
Fayed (*AB0654*)		Abstract (EULAR)	Egypt	RMD patients	100	19	No base incidence Risk estimates not (fully) adjusted
Felten		Abstract	France	IRMD patients	1,054	40	No base incidence No comparison
Fernandez-Avila		Abstract (ACR)	PANLAR countries	RMD patients	1,621	27	No base incidence No comparison
Fernandez-Ruiz	Arthritis Rheum	Full report	US	SLE patients	226	41	No base incidence Risk estimates not (fully) adjusted
Formenti	Endocrine	Letter	Italy	Osteoporosis patients	42	1	No base incidence Less than 10 participants with outcome Risk estimates not (fully) adjusted
Fredi	Lancet Rheumatol	Full report	Italy	RMD patients with COVID-19	1,525	117	No base incidence Risk estimates not (fully) adjusted

García Fernández		Abstract (ACR)	Spain	Rituximab treated RMD patients	76	8	No base incidence Less than 10 participants with outcome No comparison
García Fernández (*POS1204*)		Abstract (EULAR)	Spain	IRMD patients	152	30	No base incidence Risk estimates not (fully) adjusted
Garrido-Cumbrera		Abstract (ACR)	Europe	RMD patients	1,707	24	No base incidence No comparison
Gazzaruso	Clin Rheumatol	Letter	Italy	I. Patients hospitalised for COVID-19 II. RMD patients	I. 219 II. 115	I. 219 II. 1	No base incidence Less than 10 participants with outcome Risk estimates not (fully) adjusted
Gendelbien	Ann Rheum Dis	Correspondence	Belgium	SLE patients	225	5	No base incidence Less than 10 participants with outcome
Gentry	Lancet Rheumatol	Fulll report	US	HCQ and non-HCQ treated RMD patients	32,109	109	No base incidence Risk estimates not (fully) adjusted
George (*Concerns and*)		Abstract (ACR)	US	RMD patients	9,004	66	No base incidence Risk estimates not (fully) adjusted
George (*Concerns Healthcare*)	J Rheumatol	Full report	US	RA, SpA, PsA or SLE patients	1,517	11	No base incidence No comparison
Glintborg	RMD Open	Full report	Denmark	RMD patients	12,789	40	No base incidence No comparison
Gonzalez		Abstract (EULAR)	Spain	ts/bDMARD treated RMD patients	1,668	19	No base incidence Risk estimates not (fully) adjusted
Goyal	Ann Rheum Dis	Correspondence	India	SLE patients	845	2	No base incidence Less than 10 participants with outcome No comparison
Günendi	Rheumatol Int	Full report	Turkey	FMF patients	822	59	No base incidence Risk estimates not (fully) adjusted
Hasseli (*Older age)*	RMD Open	Full report	Germany	RMD patients with COVID-19	468	468	No base incidence Risk estimates not (fully) adjusted
Hasseli (*Do patients*)	Clin Exp Rheumatol	Full report	Germany	RA and SpA patients with COVID-19	208	208	No base incidence Risk estimates not (fully) adjusted
Hasseli (*OP0283*)		Abstract (EULAR)	Germany	RMD patients with COVID-19	1,143	1,143	No base incidence Risk estimates not (fully) adjusted
Hausmann		Abstract (ACR)	Worldwide	RMD patients	9,393	519	No base incidence Risk estimates not (fully) adjusted
Hoffmann-Vold (*POS0054*)		Abstract (EULAR)	Europe	SSc patients with COVID-19	178	178	No base incidence Insufficient information on adjustments
Howren	Clin Rheumatol	Letter	Worldwide	RMD patients	429	3	No base incidence Less than 10 participants with outcome No comparison
Ince (*POS1257*)		Abstract (EULAR)	Turkey	ANCA-associated vasculitis patients	89	15	No base incidence Risk estimates not (fully) adjusted
Islam		Abstract (APLAR)	Bangladesh	RMD patients	167	9	No base incidence Less than 10 participants with outcome No comparison
Isnardi (*POS1208*)		Abstract (EULAR)	Argentina	RMD patients with COVID-19	525	525	No base incidence Risk estimates not (fully) adjusted
Kalyoncu	Turk	Full report	Turkey	bDMARD treated RA/SpA patients	1,394	2	No base incidence

							Less than 10 participants with outcome No comparison
Kant	J Nephrology	Full report	US	ANCA-associated vasculitis patients	206	3	No base incidence Less than 10 participants with outcome No comparison
Kharouf (*POS1217*)		Abstract (EULAR)	Israel	IRMD patients with COVID-19	190	190	No base incidence No comparison
Khoubnasabjafari	Postgrad Med J	Letter	Iran	RA patients	1,858	46	No base incidence Risk estimates not (fully) adjusted
Kipps	Clin Rheumatol	Full report	UK	RMD patients	887	1	No base incidence Less than 10 participants with outcome Risk estimates not (fully) adjusted
Koltsova (*AB0703*)		Abstract (EULAR)	Russia	tDMARD treated inflammatory arthritis patients with COVID-19	78	78	No base incidence No comparison
Lahrichi (*AB0662*)		Abstract (EULAR)	Morocco	RMD patients	159	17	No base incidence No comparison
Lin	Ann Rheum Dis	Correspondence	China	Patients hospitalised with COVID-19	3,057	3,057	No base incidence No comparison
Loarce-Martos	Rheumatol Int	Full report	Spain	Rituximab treated RMD patients	76	8	No base incidence Less than 10 participants with outcome No comparison
Lohse	Clin Exp Rheumatol	Letter	France	bDMARD treated IRMD patients and non-bDMARD treated RMD patients	100	4	No base incidence Less than 10 participants with outcome Risk estimates not (fully) adjusted
Lwin	Rheumatol Adv Pract	Letter	UK	ts/bDMARD treated RMD patients	1,004	2	No base incidence Less than 10 participants with outcome No comparison
Mageau	Ann Rheum Dis	Letter	France	SLE patients with hospital stay	11,055	1,411	No base incidence Risk estimates not (fully) adjusted
Mancuso	Arthritis Care Res	Full report	US	RMD patients using medication	112	2	No base incidence Less than 10 participants with outcome No comparison
Marques (*COVID-19 in*)	Ann Rheum Dis	Correspondence	Brazil	RMD patients with COVID-19	130	130	No base incidence No comparison
Marques (*High levels*)	RMD Open	Full report	Brasil	IRMD patients with COVID-19	334	334	No base incidence Risk estimates not (fully) adjusted
Martínez-López (*POS1231*)		Abstract (EULAR)	Spain	IRMD patients with COVID-19	147	147	No base incidence No comparison
Martínez-Martínez (*POS1245*)		Abstract (EULAR)	Mexico	RMD and non-RMD patients with COVID-19	1,291	1,291	No base incidence Risk estimates not (fully) adjusted
Martire (*AB0689*)		Abstract (EULAR)	Martire	SpA patients	320	14	No base incidence No comparison
Mattioli (*POS1212*)		Abstract (EULAR)	Italy	Behçet patients	335	12	Insufficient information on COVID-19 diagnosis Risk estimates not (fully) adjusted
McKee (*OP0265*)		Abstract (EULAR)	Northern Ireland	RMD patients	2,539	198	No base incidence No comparison
Migkos	Rheumatol Int	Full report	Greece	Inflammatory arthritis patients	443	32	No base incidence No comparison

Monov (*POS1184*)		Abstract (EULAR)	Bulgaria	IRMD patients	512	89	No base incidence No comparison
Monti	Ann Rheum Dis	Letter	Italy	ts/bDMARD treated RMD patients	320	4	No base incidence Less than 10 participants with outcome No comparison
Moradi	Intern Emerg Med	Full report	Iran	RMD patients and non-RMD controls	456	27	No base incidence Risk estimates not (fully) adjusted
Morgenthau	Lung	Full report	US	COVID-19 patients	7,337	7,337	No base incidence Less than 10 participants with outcome in adjusted analyses
Murray (*POS1216*)		Abstract (EULAR)	Ireland	RMD patients	1,381	6	No base incidence Less than 10 participants with outcome Risk estimates not (fully) adjusted
Nuño	Ann Rheum dis	Letter	Spain	RMD patients with COVID-19	122	122	No base incidence Risk estimates not (fully) adjusted
Opdam (*POS1197*)		Abstract (EULAR)	The Netherlands	IRMD patients with COVID-19	275	275	No base incidence Insufficient information on adjustments
Pellegrino	Clin Rheumatol	Brief report	Italy	SSc patients	110	1	No base incidence Less than 10 participants with outcome No comparison
Quere	Joint Bone Spine	Letter	France	DMARD treated RA patients	252	1	No base incidence Less than 10 participants with outcome No comparison
Ramirez (*POS1247*)		Abstract (EULAR)	Europe	IgG4-related disease patients	305	23	No base incidence No comparison
Reyes (*POS1188*)		Abstract (EULAR)	Worldwide	RMD patients with COVID-19	1,122	1,122	No base incidence Risk estimates not (fully) adjusted
Rosenbaum (*Biologics, spondylitis*)	Ann Rheum Dis	Letter	Worldwide	SpA patients	2,992	14	No base incidence No comparison
Rosenbaum (*Correspondence on 'Factors*)	Ann Rheum Dis	Correspondence	Worldwide	SpA patients	4,310	212	No base incidence Risk estimates not (fully) adjusted
Roux (*Clinical impact*)	Clin Rheumatol	Letter	France	SpA patients	611	1	No base incidence Less than 10 participants with outcome No comparison
Roux (*Impact of home*)	Arthritis Rheum	Letter	France	SpA patients	609	18	No base incidence No comparison
Saadoun	Lancet Rheumatol	Full report	Europe	IRMD patients with COVID-19	3,028	3,028	No base incidence Risk estimates not (fully) adjusted
Salviato Pileggi (*POS1252*)		Abstract (EULAR)	Brazil	Antimalarial treated RMD patients and non-RMD household controls	10,427	1,132	No base incidence Insufficient information on adjustments
Santos (*Determinants of*)	Clin Rheumatol	Full report	Spain	RMD patients hospitalised with COVID-19	38	38	No base incidence Adjusted risk estimates not reported
Sarzi-Puttini	Autoimmunity	Full report	Italy	ts/bDMARD treated RMD patients	7,204	47	No base incidence No comparison
Seyahi	Rheumatol Int	Full report	Turkey	RMD patients and control groups (hospital workers, teachera)	2,223	21	No base incidence Risk estimates for psychiatric symptoms

Shoop-Worrall (AB0681)		Abstract (EULAR)	World	RMD patients	3,646	103	No base incidence No comparison
Singer	Ann Rheum Dis	Correspondence	US	Immunosuppressant treated RA/SLE patients with COVID-19 and two control groups	35,367	159	No base incidence Risk estimates not (fully) adjusted
Singh (*POS1422*)		Abstract (EULAR)	US	RMD patients undergoing SARS-CoV-2 PCR testing	2,768	43	No base incidence Risk estimates not (fully) adjusted
Sirotich		Abstract (ACR)	Worldwide	RMD patients	6,581	455	No base incidence Risk estimates not (fully) adjusted
Sorrentino (*POS1186*)		Abstract (EULAR)	Argentina	RMD patients with COVID-19	525	525	No base incidence Risk estimates not (fully) adjusted
Starovoytova (*POS1232*)		Abstract (EULAR)	Russia	SSc patients	110	59	No base incidence No comparison
Tamartash	Intern Emerg Med	Letter	Iran	SSc patients	150	9	No base incidence Less than 10 participants with outcome No comparison
Tejada Cifuentes	Med Clin (Barc)	Full report	Spain	Antimalarial treated RMD patients	3,817	169	No base incidence No comparison
Tomelleri	Ann Rheum Dis	Letter	Italy	Large vessel vasculitis patients	162	4	No base incidence Less than 10 participants with outcome No comparison
Trandafir (*AB0690*)		Abstract (EULAR)	Romania	RMD patients with COVID-19	81	81	No base incidence No comparison
Unlu Ozkan (*POS1244*)		Abstract (EULAR)	Turkey	RMD patients	160	23	No base incidence No comparison
Wan	Ann Rheum Dis	Correspondence	Malaysia	Patients with COVID-19	569	569	No base incidence No comparison
Wegrzyn (*POS1207*)		Abstract (EULAR)	US	RA patients with COVID-19	910	910	No base incidence Risk estimates not (fully) adjusted
Winthrop	Ann Rheum Dis	Letter	US and Canada	Immunomodulatory drug treated RMD patients with COVID-19	77	77	No base incidence Risk estimates not (fully) adjusted
Ye	Med Comm	Full report	China	IRMD patients with COVID-19	100	100	No base incidence Risk estimates not (fully) adjusted
Ye (*POS1163*)		Abstract (EULAR)	US	RA patients with COVID-19	2,948	2,948	No base incidence No comparison
Yousefghahari	Clin Rheumatol	Full report	Iran	DMARD treated IRMD patients and non-RMD controls	1,249	214	No base incidence Risk estimates not (fully) adjusted
Zhao	Ann Rheum Dis	Correspondence	China	Patients with COVID-19	3,059	3,059	No base incidence No comparison
Ziadé	Int J Rheum Dis	Full report	Arab countries	RMD patients	2,163	61	No base incidence Risk estimates for negative mental impact
Zonozi	Iran J Kidney Dis	Letter	Iran	Rituximab treated autoimmune disease patients	516	6	No base incidence Less than 10 participants with outcome No comparison
Zucchi	Plos One	Full report	Italy	SLE patients	332	6	No base incidence Less than 10 participants with outcome Risk estimates not (fully) adjusted

Supplementary Table 2. Studies only eligible for extraction of incidence data based on quality assessment (n=34).							
First author	**Journal**	**Publication type**	**Country**	**Study population**	**Total (N)**	**Confirmed COVID (N)**	**Comment**
Aries	Ann Rheum Dis	Correspondence	Germany	DMARD treated RMD patients	11,771	30	No comparison
Bachiller-Corral	J Rheumatol	Full report	Spain	IRMD patients in hospital area of care	4,592	4,592	Risk estimates not (fully) adjusted
Benucci	Ann Rheum Dis	Correspondence	Italy	bDMARD treated RMD patients	295	4	No comparison
Bjornsson	Ann Rheum Dis	Letter	Iceland	I. ts/bDMARD treated RMD patients and matched controls II. MTX treated RMD patients and matched controls	39,961	232	Risk estimates not (fully) adjusted
Bozzalla-Cassione	Ann Rheum Dis	Letter	Italy	SLE patients	251	12	No comparison
Cacciapaglia	Ann Rheum Dis	Correspondence	Italy	RA patients	1,471	6	No comparison
Chen (*Epidemiology and*)	Clin Exp Rheumatol	Letter	China	RMD patients	627	8	No comparison
Cleaton	Ann Rheum Dis	Correspondence	UK	RMD patients	1,693	61	Risk estimates not (fully) adjusted
Comarmond	Ann Rheum Dis	Correspondence	France	Large vessel vasculitis patients	148	8	No comparison
Espinosa	Clin Rheumatol	Full report	Spain	SLE patients	400	4	No comparison
Eviatar	Int Med J	Full report	Israel	RMD patients	1,204	4	Less than 10 participants with outcome Risk estimates not (fully) adjusted
Favalli (*Incidence and*)	J Rheumatol	Letter	Italy	CTD patients	123	1	No comparison
Favalli (*Incidence of*)	Arthritis Rheum	Brief report	Italy	bDMARD treated RMD patients	955	6	No comparison
Ferri (*COVID-19 and rheumatic*)	Clin Rheumatol	Full report	Italy	IRMD patients	1,641	11	Risk estimates not (fully) adjusted
Ferri (*COVID-19 and systemic*)	Lancet Rheumatol	Comment	Italy	SSc patients	1,636	14	Risk estimates not (fully) adjusted
Ferri (*POS1246*)		Abstract (EULAR)	Italy	IRMD patients	2,994	22	Risk estimates not (fully) adjusted
Flood	Ann Rheum Dis	Correspondence	Ireland	RMD patients with COVID-19	78	78	Risk estimates not (fully) adjusted
Francesconi	Joint Bone Spine	Letter	Italy	General population	2,6 mln	4581	Risk estimates not (fully) adjusted
Jovani	Ann Rheum Dis	Correspondence	Spain	ts/bDMARD treated IRMD patients	1,037	3	No comparison
Melong Pianta		Abstract (ACR)	Switzerland	IFX and RTX treated RMD patients	142	15	Less than 10 participants with outcome Risk estimates not (fully) adjusted
Mena Vázquez *(Incidence and)*	Int J Clin Pract	Full report	Spain	RA, PsA and SpA patients suspected of COVID-19 and non-RMD patients suspected of COVID-19	1,537	520	Less than 75 participants studied for risk factors
Michelena	Semin Arthritis Rheum	Full report	Spain	ts/bDMARD treated RMD patients	959	11	Risk estimates not (fully) adjusted 'suspected' COVID-cases included in analysis
Moiseev	Ann Rheum Dis	Correspondence	Russia	Patients on ICU with COVID-19	902	902	No comparison
Murray	Rheumatology	Concise report	Ireland	Immunosuppressive medication treated RMD patients	1,381	6	No comparison
Pablos (*Prevalence of*)	Ann Rheum Dis	Full report	Spain	General population and RMD patients from registry	2.9 mln	26131	Risk estimates not (fully) adjusted
Profili	Epidemiol Prev	Full report	Italy	General population	1.1 mln	1840	Risk estimates not (fully) adjusted
Quartuccio (*Prevalence of*)	Joint Bone Spine	Full report	Italy	ts/bDMARD treated RMD patients	1,051	4	No comparison

Quartuccio (*Timing of*)	Rheumatology	Letter	Italy	Rituximab treated ANCA-associated vasculitis patients	100	2	No comparison
Ramirez	Semin Arthritis Rheum	Full report	Italy	SLE patients	417	5	Less than 10 participants with outcome
Salvarani	Arthritis Rheumatol	Brief report	Italy	Antimalarial treated RMD patients	4,408	30	Risk estimates not (fully) adjusted
Salvarini	Ann Rheum Dis	Letter	Italy	ts/bDMARD treated RMD patients	1,195	9	No comparison
Santos (*Biological agents*)	RMD Open	Full report	Spain	bDMARD treated RMD patients	820	40	Risk estimates not (fully) adjusted
So	Semin Arthritis Rheum	Full report	China	RMD patients with COVID-19	1,067	5	No comparison
Zen	J Autoimmunity	Full report	Italy	IRMD patients	916	2	No comparison

Supplementary Table 3: Risk of bias of cohort studies

Supplementary Table 3. Risk of bias of cohort studies (Newcastle-Ottawa Scale).										
First author	**S1**	**S2**	**S3**	**S4**	**C1**	**O1**	**O2**	**O3**	**Final judgment**	**Comment**
Bachiller-Corral	+	+	+	±	+	+	±	±	High	An important caveat is selection by indication bias.
Bjornsson	+	-	+	+	+	+	+	+	Low	-
Boteanu (POS1260)	-	-	+	+	+	+	+	-	Unclear	Likely risk of selection bias (method of selection not reported), no information on RMD diagnosis and unclear how many centers actually participated in the study.
Bower	+	+	+	±	+	+	±	±	Low	-
Braun-Moscovici (pre-print)	+	-	+	-	-	±	+	-	High	Important caveats include lack of a control group and lack of reporting on the follow-up period.
Chandan	+	+	+	+	+	+	+	+	Low	-
Cleaton	-	+	-	-	+	-	±	±	High	Important caveats include high risk of selection bias (based on availability of mobile phone numbers), uncertainties about exposure- and outcome ascertainment.
Cordtz	+	+	+	+	+	+	±	±	Low	-
Cuomo (POS1248)	-	-	-	-	-	+	+	±	High	Important caveats include high risk of selection bias (and uncertainties about exposure ascertainment.
Deepak (pre-print)	±	-	-	+	+	+	+	+	High	An important caveat is the risk of selection bias (method of selection not reported).
D'Silva	+	+	+	+	+	+	+	+	Unclear	Study at risk of selection bias and confounding by indication; the use of ICD-10 codes in health record data is also prone to misclassification of exposure as well as outcome.
England	+	+	+	±	+	+	±	±	Low	-
FAI consortium	+	-	+	±	+	+	±	±	Unclear	Important caveats are risk of selection bias and confounding by indication.
Fernandez-Gutierrez	+	+	-	+	+	+	±	±	Unclear	Important caveats are unclear case ascertainment and absence of control group.
Fike	+	+	+	-	+	+	±	±	Unclear	Important caveat is selection bias.
Flood	+	+	+	-	+	+	±	±	Unclear	Important caveat is selection bias.
Freites (POS1253)	-	-	+	+	+	-	+	-	Unclear	Important caveats are selection bias unclear (criteria not reported), no description of collection of outcome data so unclear risk of misclassification of death, risk of misclassification of COVID-19 (cases with physician diagnosis without testing included) and risk of confounding by indication by selective PCR testing due to availability of tests).
Freites-Nunez	+	-	+	-	-	+	±	±	High	An important caveat is the lack of a control group and unclear exposure ascertainment.

Furer	+	-	+	-	-	+	+	+	Low	-
Geisen	-	-	+	+	-	+	+	±	Unclear	An important caveat is that the conclusion is severely overstated.
Haberman	-	+	+	+	+	+	+	+	Unclear	Although rated as 8 stars, there is high risk of selection bias due to method of selection and risk of overinterpretation of results with low numbers in each subgroup.
Hsu (POS1774)	+	+	+	-	+	+	±	±	Unclear	-
Jorge	+	+	+	+	+	+	+	±	Unclear	High risk of selection bias due to method of selection and use of ICD-10 codes in health record data is also prone to misclassification of exposure as well as outcome.
Jovani	-	-	-	+	-	-	+	-	High	High risk of selection bias, high risk of confounding by indication of PCR testing, unclear how PCR data were collected.
Jung	+	+	+	+	+	+	+	+	Unclear	High risk of confounding by indication of PCR testing; the use of ICD-10 codes in health record data is also prone to misclassification of exposure as well as outcome.
Kim	+	+	+	+	+	+	±	±	Unclear	An important caveat is unclear diagnosis ascertainment and incomplete adjustment on confounding variables.
Lopez-Guitierrez	+	+	+	-	+	+	±	±	Unclear	-
Madrid-Garcia	+	+	-	+	+	+	±	±	Unclear	An important caveat is unclear exposure to colchicine (uncertain and not quantified).
Moiseev	+	-	+	-	-	+	±	±	High	Important caveats include lack of a control group and lack of adjustment for possible confounders.
Pablos *(Clinical outcomes)*	-	+	+	+	+	+	+	+	Unclear	High risk of selection bias as well as risk of confounding by indication of PCR testing.
Pablos *(Prevalence of)*	+	+	+	±	+	+	±	±	High	Important caveats include selection by indication bias.
Pakchanian	+	+	+	-	+	+	±	±	Unclear	Important caveats include selection bias, representativeness and selection of not-exposed.
Perez Sancristobal (POS1251)	-	-	+	+	+	-	+	-	Unclear	Important caveats are selection bias unclear (criteria not reported), no description of collection of outcome data so unclear risk of misclassification hospitalisation for COVID-19, risk of misclassification of COVID-19 (cases with physician diagnosis without testing included) and risk of confounding by indication by selective PCR testing due to availability of tests.
Quartuccio *(Prevalence of)*	+	-	+	+	-	-	+	-	Unclear	High risk of confounding by indication because PCR only performed in selected patients due to availability of testing.
Quartuccio (*Timing of)*	-	-	+	+	-	-	+	-	High	Likely risk of selection bias (method of selection not reported), high risk of confounding by indication because PCR only performed in selected patients due to availability of testing, and no information on RMD diagnosis.
Rentsch	+	+	-	+	-	-	±	±	High	Important caveats: ascertainment of diagnosis is uncertain (patient population: exposed to HCQ, not RMDs+), ascertainment of test is uncertain. Incomplete adjustment on confounding variables.

Salvarani *(Susceptibility and)*	+	-	-	+	-	+	+	+	Unclear	Particularly high risk of confounding by indication because PCR only performed in symptomatic patients and risk of misclassification of RMD diagnosis.
Salvarani *(Susceptibility to)*	+	-	-	+	-	+	+	+	Unclear	Particularly high risk of confounding by indication because PCR only performed in symptomatic patients and risk of misclassification of RMD diagnosis.
Santos	+	+	+	-	+	+	±	±	Unclear	Risk of selection bias and unclear ascertainment of outcome at study start.
Sbidian	+	+	-	+	-	+	±	±	Unclear	Adjustment made on some cofounding factors but not all and ascertainment of outcome is unclear (hospitalization for COVID, but no PCR test).
Serling-Boyd	-	+	+	-	+	+	+	±	Unclear	Risk of selection bias and confounding by indication for PCR testing.
So	+	+	+	+	-	+	±	±	High	Important caveats include lack of a control group and lack of statistical analysis.
Spiera	-	-	+	+	-	+	-	-	High	-
Topless	-	+	+	+	+	+	+	-	Unclear	High risk of selection bias and risk of misclassification of exposure (RA/gout) and outcome (serology data unreliable, at risk of selective testing, as well as large differences in important baseline characteristics in disease vs control group.
Vila-Córcoles	+	-	+	+	-	+	±	±	High	-
Yang	-	-	-	+	-	-	+	-	High	-
Wong (POS1255)	+	+	+	+	+	+	+	+	Unclear	Important caveat is basing the main exposure on prescription with dose not indicated and the reason for disease selection are unclear.

S1: Representativeness; S2: Selection of non-exposed; S3: Exposure ascertainment; S4: Outcome not at start; C1: Comparability; O1: Outcome assessment; O2: Duration follow-up; O3: Adequacy follow-up. Light green = no concerns; light yellow = some concerns; light red = several concerns.

Supplementary Table 4: Risk of bias of cross-sectional studies

Supplementary Table 4. Risk of bias of cross-sectional studies (AXIS tool).																						
First author	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Final judgment**	**Comment**
Alpizar Rodriguez	+	+	-	±	+	±	±	+	±	+	±	+	±	±	+	+	+	-	+	+	High	Important issues include high risk of selection bias (voluntary enrollment) and ascertainment of outcome is uncertain: no info on COVID-19 cases diagnosis.
Aries	+	+	-	+	+	+	±	+	+	-	-	-	±	±	-	-	+	-	+	-	High	Important issues include high risk of selection bias, lack of description of the cohort and of the statistical analysis, and lack of internal consistency.
Avouac	+	+	-	+	±	±	±	+	±	+	+	+	±	±	+	+	+	+	+	+	Unclear	Important issues include high risk of selection bias due to method of inclusion of patients into registry and risk of confounding by indication.
Benucci	+	±	-	+	+	±	±	+	+	+	+	-	±	±	+	+	+	-	+	+	High	Important issues include high risk of selection bias due to method of inclusion, unclear case-ascertainment and absence of control group.
Blanch-Rubio	+	+	-	+	+	+	±	+	+	+	+	+	±	±	+	+	+	+	+	+	High	Important issues include lack of proper method description, risk of confounding by indication of case ascertainment and unclear case ascertainment.
Boyarsky	+	-	-	+	-	-	±	±	+	±	-	+	+	+	+	±	+	+	+	+	High	Important issues include high risk of selection bias due to method of inclusion, unclear case-ascertainment and unclear outcome ascertainment.
Bozzalla-Cassione	+	±	-	+	+	±	±	+	+	-	-	+	±	±	+	-	-	±	+	+	High	Important issues include high risk of selection bias due to method of inclusion, unclear case-ascertainment and absence of control group.
Chen	+	+	-	+	+	+	±	+	+	-	-	-	±	±	+	+	+	-	+	+	Unclear	Important issues include high risk of selection bias, lack of proper description of the cohort and of the statistical analysis.
Comarmond	+	±	-	+	+	±	-	+	+	+	-	-	±	-	+	+	-	-	+	+	High	Important issues include unclear patient selection, high risk of selection bias and risk of confounding by indication of PCR testing.
Connolly	+	-	-	+	-	-	±	±	+	±	-	+	+	+	+	±	+	+	+	+	High	Important issues include particularly high risk of selection bias due to method of inclusion of patients and lack of base population.
Esatoglu	+	+	-	+	+	-	±	+	+	+	+	±	±	±	+	+	+	+	+	+	High	Important issues include particularly high risk of selection bias due to method of selection of patients, very limited adjustment on confounders and absence of control group.
Espinosa	+	+	-	+	+	-	±	+	-	+	+	+	±	±	+	+	+	+	±	+	High	Important issues include particularly high risk of selection bias due to method of selection of patients, unclear case ascertainment, very limited adjustment on confounders and absence of control group.
Eviatar	+	+	-	+	+	-	±	+	+	+	+	±	±	±	+	+	+	+	+	+	High	Important issues include particularly high risk of selection bias due to method of selection of patients, unclear case and outcome ascertainment.

Favalli *(Incidence of)*	+	+	-	+	+	+	±	+	+	+	+	±	±	±	+	+	+	+	±	+	Unclear	Important issues include insufficient description of baseline population.
Favalli *(Incidence and)*	+	+	-	+	+	+	±	+	+	-	-	+	±	±	+	-	+	-	-	+	Unclear	Important issues include insufficient description of methods.
Ferri *(COVID-19 and rheumatic; COVID-19 and systemic; POS1246)*	+	-	-	-	-	+	±	+	-	+	+	+	±	±	+	+	±	-	+	+	High	Important issues include unclear patient selection, unclear whether measurement of COVID-19 outcome is appropriate, insufficient description of methods, no adjustment for confounding and high risk of selection bias and confounding by indication of PCR testing.
Gianfrancesco *(Characteristics associated)*	+	±	+	+	+	-	-	+	+	+	+	+	±	-	+	+	+	+	+	+	Unclear	Important issues include particularly high risk of selection bias due to method of inclusion of patients and risk of confounding by indication.
Gianfrancesco *(Association of)*	+	+	-	+	±	-	±	+	-	+	+	+	±	±	+	+	+	+	+	+	Unclear	Important issues include particularly high risk of selection bias (voluntary enrollment) and ascertainment of cases is uncertain.
Haberman	+	+	-	+	±	+	-	±	+	+	+	+	+	-	+	+	+	+	+	+	Low	-
Juge *(POS1227)*	+	+	-	+	+	-	±	+	+	+	+	±	±	±	+	+	+	-	+	+	High	Important issues include particularly high risk of selection bias due to method of selection of patients, small number of cases and very limited adjustement on confounders.
Machado *(LB0002)*	+	+	-	+	+	±	-	+	+	+	±	+	±	±	+	+	+	±	+	±	Unclear	Important issues include high risk of selection bias due to method of inclusion of patients into registry and lack of information on vaccination efficacy (immune response) in addition to safety.
Melong Pianta	±	±	-	+	+	±	-	±	±	±	-	+	+	-	+	+	-	-	+	±	High	Important issues include unclear patient selection, unclear whether measurement of COVID-19 outcome is appropriate, insufficient description of methods, no adjustment for confounding, high risk of selection bias and confounding by indication of PCR testing.
Mena Vázquez *(Incidence and)*	+	±	-	+	-	-	±	+	+	+	+	+	+	-	+	+	±	+	+	+	High	Important issues include particularly high risk of selection bias due to inappropriate base population and method of selection of patients, small number of cases, confounding by indication of PCR testing, and relatively short follow-up duration (1 month) which may have biased conclusions.
Michelena	+	+	-	+	+	+	-	+	+	±	+	+	±	±	+	+	+	+	+	+	Unclear	Important issues include particularly high risk of selection bias.
Murray	+	-	-	-	-	-	±	+	-	-	+	+	±	±	+	+	±	+	+	+	High	Important issues include risk of selection bias, unclear ascertainment of cases and outcomes is uncertain and lack of control group.
Ramirez *(Correspondence on)*	+	±	-	+	-	±	-	+	+	-	±	+	±	-	+	±	±	-	+	+	High	Important issues include unclear selection of patients, likely bias due type of patients sampled (54/55 health professionals) and overinterpretation of data.
Ramirez *(COVID-19 in)*	±	+	-	+	+	+	±	±	±	+	+	+	±	±	+	±	+	+	+	±	High	Important issues include particularly high risk of selection bias due to method of inclusion of patients and inappropriate control group.

Ruddy	+	±	-	+	±	-	-	±	±	+	±	±	±	-	+	±	+	±	+	+	Unclear	Important issues include particularly high risk of selection bias due to method of inclusion of patients, risk of confounding by indication, risk of misclassification of exposure (RMD type and RMD medication) and measurement of surrogate outcome of vaccination efficacy.
Scirè	+	±	+	+	+	-	-	+	±	+	+	+	±	-	+	+	±	±	+	+	Unclear	Important issues include unclear whether measurement of COVID-19 outcome is appropriate, particularly high risk of selection bias due to method of inclusion of patients and confounding by indication of PCR testing.
Simon	+	±	-	+	±	+	-	±	±	+	±	+	±	-	+	+	+	-	+	+	Unclear	Important issues include unclear selection of patients into larger cohort and non-selected patients from that cohort, possible overinterpretation of data due to small subgroups in several analyses, unclear how IMID diagnosis and medication are measured.
Sparks	+	±	±	+	+	-	-	+	+	+	+	+	±	-	+	+	+	+	+	+	Unclear	Important issues include particularly high risk of selection bias due to method of inclusion of patients and risk of confounding by indication; the authors tried to mitigate the risk of confounding by indication by the selection of a homogeneous RA population and in the way the data was modelled, but this remains a concern.
Strangfeld	+	±	+	+	+	-	-	+	+	+	+	+	±	-	+	+	+	+	+	+	Unclear	Important issues include particularly high risk of selection bias due to method of inclusion of patients and confounding by indication.
Trefond	+	±	-	+	+	-	-	+	+	±	±	+	±	-	+	±	+	±	+	+	Unclear	Important issues include particularly high risk of selection bias due to method of inclusion of patients into registry, unclear risk of misclassification of exposure to HCQ because of limited description, risk of confounding by indication, as well as very basic statistical analysis.
Ugarte-Gil *(OP0286)*	+	+	±	+	+	±	±	+	+	+	-	+	±	±	+	±	+	+	+	+	Unclear	Important issues include high risk of selection bias due to method of inclusion of patients into registry.
Zen	+	+	-	+	+	+	+	+	±	+	+	+	+	+	+	+	+	-	+	+	Unclear	Important issues include unclear whether measurement of COVID-19 outcome is appropriate, risk of selection bias and confounding by indication of PCR testing, and relatively short follow-up duration (<1 month) which may have biased conclusions.
Zhong	+	-	-	+	+	±	±	+	+	+	+	-	±	±	+	+	-	+	+	±	High	Important issues include high risk of selection bias due to method of inclusion of patients, lack of detailed characterization of the cohort and overinterpretation of data.

1: Objective; 2: Study design; 3: Sample size; 4: Target population; 5: Appropriate base population; 6: Selection; 7: Non responders; 8: Variable measurement; 9: Valid instruments; 10: Statistical significance; 11: Sufficient description; 12: Basic data description; 13: Response rate; 14: Information non-reponders; 15: Internal consistency; 16: Selective reporting; 17: Conclusion justified; 18: Limitations; 19: Conflict of interest; 20: Ethical approval. Light green = no concerns; light yellow = some concerns; light red = several concerns.

Supplementary Table 5: Risk of bias of case-control studies

Supplementary Table 5. Risk of bias of cohort studies (Newcastle-Ottawa Scale).										
First author	**S1**	**S2**	**S3**	**S4**	**C1**	**E1**	**E2**	**E3**	**Final judgement**	**Comment**
Alegiani	+	-	±	±	+	+	+	±	Unclear	Risk of confounding by indication.
Francesconi	-	-	+	-	+	+	+	-	High	High risk of selection bias, confounding by indication of PCR testing and unclear source of data of both cases and controls.
Ji	-	+	+	+	+	+	+	±	Unclear	Unclear case ascertainment.
Mena Vázquez *(Hospitalization and)*	+	-	+	-	+	-	±	±	High	High risk of selection bias and unclear case ascertainment.
Profili	-	-	-	-	+	-	±	±	High	High risk of selection bias by design and case uncertainty.

S1: Case definition; S2: Representativeness; S3: Selection controls; S4: Definition controls; C1: Comparability; E1: Ascertainment exposure; E2: Same method ascertainment; E3: Non-response rate. Light green = no concerns; light yellow = some concerns; light red = several concerns.

Supplementary Table 6: Incidence of COVID-19 in patients with RMDs

Table 1. Studies with data on the incidence of COVID-19 in patients with RMDs compared to persons without RMDs													
First author	**Country**	**Cohort**	**Study period**	**Study type**	**Setting**	**Study population; recruitment**	**Case definition RMD**	**Case definition COVID-19**	**Source population of base incidence**	**Incidence in RMD patients**	**Base incidence**	**Incidence in RMD patients vs base population** (higher, equal, lower)	**RoB**
Aries	Germany	Hamburg COVID-19 registry	Until 9 Jun 20	Cross-sectional, registry	Secondary care	DMARD treated RMD patients with COVID-19; cases reported by rheumatologists	Physician diagnosis	Symptoms and PCR+ or IgG+	General population in region	30/11,771 (0.3%)	5,120/1,8 mln (0.3%)	Equal	
Benucci	Italy	Incidence COVID-19 Rheumatic Disease Biologics study	25 Mar to 25 May 20	Cross-sectional	Secondary care	bDMARD treated RMD patients; consecutive patients at outpatient clinic during study period	Physician diagnosis	PCR+	General population in region	4/295 (1.4%, 0.4-3.4)	7,393/1,6 mln (0.5%, 0.4-0.5)	Higher (OR 3.01, 1.13-8.09)	
Bjornsson	Iceland	ICEBIO	Until 3 Jun 20	Retrospective, registry, matched	Population-based	ts/bDMARD treated RMD patients and MTX treated RMD patients; data from national registries	Physician diagnosis	PCR+	General population registries, matched (age, sex, location)	9/1,438 (0.6%) [ts/bDMARD], 5/1,746 (0.3%) [MTX]	84/13,815 (0.6%) [ts/bDMARD controls], 134/22,962 (0.6%) [MTX controls]	Equal	
Blanch-Rubio	Spain	-	1 Mar to 3 May 20	Cross-sectional	Secondary care	Patients with OP, OA or FM; regularly attended outpatient clinic in previous 6 months	Physician diagnosis	Physician diagnosis (confirmed or highly suspected)	General population in region	109/2102 (age-adjusted cumulative incidence 4.7%, 3.8-5.6) [all], 3.0% (1.9-4.1) [OP], 4.6% (3.5-5.7) [OA], 4.5% (2.8-6.1) [FM]	Age-adjusted cumulative incidence 3.69% (3.66-3.73)	Equal	
Bozzalla-Cassione	Italy	-	15 Feb to 6 Apr 20	Cross-sectional	Secondary care	Patients with SLE; followed at outpatient clinic	Physician diagnosis	PCR+ or contact with case and symptoms	General population in two regions	4/165 (2.5%) [confirmed], 12/165 (7.2%) [confirmed and suspected]	0.47% and 0.76%	Higher	
Chen	China	-	Until 24 Mar 20	Cross-sectional	Secondary care	Patients with RMD; followed at outpatient clinic from Jul 18 to Jan 20	Physician diagnosis	COVID-19 diagnostic criteria 5th Edition	General population in region	8/627 (1.3%, 0.4-2.2)	67,801/57mln (0.12%)	Higher (OR 10.9, 5.4-21.9)	
Comarmond	France	-	4 May to 20 May 20	Cross-sectional	Secondary care	Patients with TAK or GCA; followed at outpatient clinic	Physician diagnosis	PCR+ or typical CT imaging or serology+	General population in region	8/148 (5.4%)	12.3%	Lower	
Espinosa	Spain	-	8 Apr to 12 May 20	Cross-sectional	Secondary care	Patients with SLE; attended outpatient clinic in previous 6 months or scheduled visit in study period	Classification criteria	PCR+	General population in region	4/400 (1.0%)	0.6%	Equal (p=0.456)	
Eviatar	Israel	-	31 Apr 20	Cross-sectional	Secondary care	Patients with RMD; attended outpatient clinic between Mar 19 and Apr 20	Physician diagnosis	PCR+	General population in country	2/1201 (0.16%) [all], 2/895 (0.22%) [inflammatory RMD]	16,246/8,884,000 (0.18%)	Equal (p=0.912 for all, p=0.759 for inflammatory RMD)	
Favalli (*Incidence and*)	Italy	-	25 Feb to 25 Mar 20	Cross-sectional	Secondary care	Patients with SLE, SSc, uCTD or SjS; attended outpatient clinic in study period (face-to-face or by telephone if a physical appointment was missed)	Physician diagnosis	Self-reported PCR+	General population in region	1/123 (0.81%)	0.62%	Equal	
Favalli (*Incidence of*)	Italy	-	25 Feb to 10 Apr 20	Cross-sectional	Secondary care	ts/bDMARD treated RMD patients; attended outpatient clinic in study period	Physician diagnosis	Self-reported PCR+ or contact with case and symptoms	General population in region	6/955 (0.62%, 0.25-1.4) [confirmed], 11/955 (1.1%) [confirmed and suspected]	57,592 cases (0.66%)	Equal (p=0.92; 0.62% vs 0.66%)	
Ferri *(COVID-19 and rheumatic; COVID-19 and systemic; POS1246)*	Italy	-	15 Mar to 25 Apr 20	Cross-sectional	Secondary care	Patients with inflammatory RMD; NR ('unselected', 'consecutive patients')	Physician diagnosis	Self-reported PCR+ or fever or contact with case and ≥4 symptoms	General population in country	22/2,994 (0.73%) [all], 14/1,636 (0.85%) [SSc], 19/1,901 (0.99%) [CTD+AAV], 3/1,093 (0.27%) [IA]	349/100,000 (0.35%)	Higher (all: p=0.0007, SSc: OR 2.47, 1.44-4.21, CTD+AAV > IA p=0.036)	
Fike	US	Observational RMD cohort at NIAMS	1 Apr to 15 Oct 20	Prospective	Secondary care	Latino patients with RMD; all cohort participants were contacted before 1 Jun 20 and those who attended outpatient clinic in study period were included in analysis	Physician diagnosis	PCR+ or serology+	Latino residents in region and all residents in region	32/178 (IR 17,978/100,000)	IR 4,689-5,809/100,000 [Latino] and IR 1,540-3,431/100,000 [all]	Higher	
Flood	Ireland	-	Until 3 Jun 20	Retrospective	Secondary care	Patients with RMD; all patients followed at outpatient clinic	Physician diagnosis	PCR+ or physician diagnosis, community acquired	General population in city	68/7500 (IR 884/100,000 [inflammatory RMD] and 940/100,000 [non-inflammatory RMD])	IR 887/100,000	Equal	
Melong Pianta	Switzerland	-	1 Mar to 30 May 20	Cross-sectional	Secondary care	IFX/RTX treated RMD patients; all patients treated at clinic	Physician diagnosis	Self-reported PCR+	General population in region	15/142 (10.5%), 9/142 (13.8%) [IFX], 6/142 (7.0%) [RTX]	9.7%	Equal	
Mena Vázquez *(Incidence and)*	Spain	-	13 Mar to 12 Apr 20	Cross-sectional	Secondary care	Patients with RA, PsA or SpA suspected of COVID-19; data from health records of patients admitted to emergency care	Classification criteria	Spanish Ministry of Health classification (confirmed, probably and possible)	Other patients at emergency care suspected of COVID-19	13/2,480 (0.52%, 0.37-0.72) [RA], 5/1,754 (0.34%, 0.22-0.52) [PsA], 5/786 (0.63%, 0.30-1.1) [SpA]*	0.50% (0.50-0.51)	Equal	
Michelena	Spain	-	26 Mar to 10 Apr 20	Cross-sectional	Secondary care	ts/bDMARD treated RMD patients; all patients treated at clinic	Physician diagnosis	Self-reported PCR+	General population in region	11/959 (age- and sex-adjusted IR 1.21%, 0.42-1.99)	Age- and sex-adjusted IR 0.58% (0.56-0.60)	Equal	

Murray	Ireland	-	28 Apr to 5 May 20	Cross-sectional	Population-based	Patients with RMD; online survey through Arthritis Ireland website and social media	Self-reported diagnosis	Self-reported PCR+	General population in country	6/1298 (0.46%)	0.44%	Equal	
Pablos (*Prevalence of*)	Spain	RIER network	7 Apr to 17 Apr 20	Retrospective	Secondary care	Patients with inflammatory RMD; all patients followed at seven RIER centres	Physician diagnosis	PCR+	General population referred to same hospitals	0.76% (0.66-0.87) [all], 0.57% (0.44-0.73) [RA], 0.57% (0.37-0.82) [PsA], 0.89% (0.63-1.22) [SpA], 1.54% (1.10-2.10) [non-SLE IMID], 0.62% (0.34-1.04) [SLE], 1.45% (0.89-2.23) [PMR/GCA]	0.58% (0.57-0.59)	Higher for all (OR 1.32, 1.15-1.52), SpA (1.54, 1.11-2.13), non-SLE IMID (2.69,1.96-3.69), PMR/GCA (2.53, 1.62-3.93); Equal for RA (OR 0.98, 0.76-1.26), PsA (0.97, 0.67-1.43), SLE (1.07 (0.63-1.80)	
Quartuccio (*Prevalence of*)	Italy	-	29 Feb to 25 Apr 20	Retrospective	Secondary care	ts/bDMARD treated RMD patients; treated between Sep 19 to Apr 20 (pharmacy data)	Physician diagnosis	PCR+	General population in region	4/1,051 (IR 3.8/1000, 1.5-9.7/1000)	937/466,700 (IR 2/1000, 1.9-2.1/1000)	Equal (p=0.33)	
Quartuccio (*Timing of*)	Italy	-	Feb to Dec 20	Retrospective	Secondary care	RTX treated AAV patients; NR	Physician diagnosis	PCR+	General population in region	2/100 (2%)	29,680/466,700 (6.3%)	Equal	
Ramirez (*COVID-19 in*)	Italy	-	17 Apr to 27 Apr 20	Cross-sectional	Secondary care	Patients with SLE; all patients followed at three outpatient clinics	Physician diagnosis	Self-reported PCR+	General population in region	5/417 (1.2%)	73,479 cases (0.73%)	Equal	
Salvarani (*Susceptibility and*)	Italy	-	Until 24 Apr 20	Retrospective	Secondary care	ts/bDMARD treated RMD patients; treated since Dec 19 (pharmacy data)	Physician diagnosis	PCR+	General population in region	9/25 tested (36.0%)	3,746/7,947 tested (47.1%)	Equal (p=0.32)	
Salvarani (*Susceptibility to*)	Italy	-	Until 13 May 20	Retrospective	Secondary care	Antimalarial treated RMD patients; treated from Jul to Dec 19 (pharmacy data)	Physician diagnosis	PCR+	General population in region	31/4,408 (0.70%)	11,563/2,104,319 (0.55%)	Equal (age- and sex-adjusted OR 0.94, 0.66-1.34)	
So	China	CDARS	Until 27 May 20	Retrospective	Secondary care	Patients with inflammatory RMD and COVID-19; data from hospital records	ICD-9 codes, verified in hospital records	PCR+	General population in region	5/39,835 (0.0126%)	1,067/7,5 mln (0.0142%)	Equal	
Zen	Italy	-	9 Apr to 25 Apr 20	Cross-sectional	Secondary care	Patient with SLE, AAV, SSc, RA or IIM; all SLE patients from local cohort and sample of other RMD patients followed at outpatient clinic	Physician diagnosis	PCR+	General population in region	2/916 (0.21%) (2/65 (3.1%) tested)	0.3%	Equal	

*Number of patients at risk was estimated, using the estimated total adult population served by the emergency department and the estimated prevalence of the investigated RMDs in the country. Colours denote overall RoB assessment of each study (green: low risk of bias, orange: unclear risk of bias, red: high risk of bias).

AAV, ANCA-associated vasculitis; (ts/b)DMARD, (targeted synthetic/biologic) disease-modifying anti-rheumatic drug; CT, computerized tomography; (u)CTD, (undifferentiated) connective tissue disease; FM, fibromyalgia; GCA, giant cell arteritis; IFX, infliximab; IIM, idiopathic inflammatory myopathies; IMID, immune mediated inflammatory disorders; IR, incidence rate; mln, million; MTX, methotrexate; NR, not reported; OA, osteoarthritis; OP, osteoporosis; OR, odds ratio; PCR, polymerase chain reaction; PMR, polymyalgia rheumatica; PsA, psoriatic arthritis, RA, rheumatoid arthritis; RMD, rheumatic and musculoskeletal diseases; RoB, risk of bias; RTX, rituximab; SjS, Sjögren syndrome; SLE, systemic lupus erythematosus; SpA, spondyloarthritis; SSc, systemic sclerosis; TAK, Takayasu arteritis; US, United States.

Supplementary Table 7: Prevalence of patients with RMDs in a COVID-19 population

Supplementary Table 6. Studies with data on the prevalence of RMDs in patients with COVID-19													
First author	**Country**	**Cohort**	**Study period**	**Study type**	**Setting**	**Study population; recruitment**	**Case definition RMD**	**Case definition COVID-19**	**Source population of base incidence**	**Incidence of RMD in COVID-19 patients**	**Base incidence of RMD**	**Incidence of RMD in COVID-19 vs base population** (higher, equal, lower)	**RoB**
Francesconi	Italy	-	Feb to Jul 20	Case-control	Population-based	Patients with COVID-19 (cases) and general population (controls); NR	Hospital discharge or payment exemption data	PCR+	General population	93/4,581 (2.0%) [inflammatory arthritis] and 23/4,581 (0.5%) [CTD]	28,366/2,589,374 (1.1%) [inflammatory arthritis], 11,879/2,589,374 (0.5%) [CTD]	Higher for inflammatory arthritis (age- and sex-adjusted OR 1.62, 1.32-1.99); Equal for CTD (age- and sex-adjusted OR 1.06, 0.70-1.60)	
Ji	Korea	HIRA insurance claims database	Until 15 May 20	Case-control	Population-based	[I] Patients with COVID-19 (cases) and general population (controls); [II] Patients with 'severe COVID-19'* (cases) and mild COVID-19 (controls); data from national insurance claims database	KCD-7	PCR+	General population	[I] 186/7,341 (2.5%) [RA], 39/7,341 (0.5%) [CTD], 633/7,341(8.6%) [OP]; [II] 33/954 (3.5%) [RA], 7/954 (0.7%) [CTD], 184/954 (19.3%) [OP]	5,853/212,620 (2.8%) [RA], 2,410/7,341 (1.1%) [CTD], 20,467/212,620 (9.6%) [OP]; [II] 153/6,387 (2.4%) [RA], 32/6,387 (0.5%) [CTD], 449/6,387 (7.0%) [OP]	[I] Higher for CTD (p<0.001), OP (p=0.004); Equal for RA (p=0.259); [II] Higher for OP (p<0.001); Equal for RA (p=0.051), CTD (p=0.356)	
Moiseev	Russia	-	NR	Retrospective	ICU	Patients with COVID-19 on ICU	Physician diagnosis	PCR+ and typical CT imaging	General population	10/902 (1.1%)	1-2%	Equal	
Profili	Italy	-	Until 11 May 20	Case-control	Population-based	Patients with COVID-19 (cases) and general population (controls); data from regional databases	Hospital codes (type of RMD not specified)	PCR+	General population living in area on 1 Jan 20	88/1,840 (4.8%, 3.8-5.8)	2.3%	Higher (age- and sex-adjusted OR 1.82, 1.46-2.25)	
Vila-Córcoles	Spain	-	1 Mar to 30 Apr 20	Retrospective	Population-based	All persons aged ≥50 in area with active clinical history; data from hospital records	ICD-10 codes of RA and SLE	PCR+	Persons in cohort without COVID-19	2/349 (0.6%)	871/79,071 (1.1%)	Equal (p=0.343)	

*'severe COVID-19' was defined as having claim data for oxygen therapy, mechanical ventilation, extracorporeal membrane oxygenation, or cardiopulmonary resuscitation. Colours denote overall RoB assessment of each study (green: low risk of bias, orange: unclear risk of bias, red: high risk of bias).

CT, computerized tomography; (u)CTD, (undifferentiated) connective tissue disease; ICU, intensive care unit; KCD-7, Korean Standard Classification of Diseases and Causes of Death 7th Edition (modified version of ICD-10); NR, not reported; OR, odds ratio; OP, osteoporosis; PCR, polymerase chain reaction; RA, rheumatoid arthritis; RMD, rheumatic and musculoskeletal diseases; RoB, risk of bias; SLE, systemic lupus erythematosus.

Supplementary Table 8: Demographics as risk factor for developing (severe) COVID-19

Supplementary Table 7. Studies with data on demographic risk factors for developing (severe) COVID-19 in patients with RMDs														
First author	**Country**	**Cohort**	**Study period**	**Study type**	**Setting**	**Study population; recruitment**	**Case definition RMD**	**Case definition COVID-19**	**Total n/N with outcome**	**Risk factor (n/N or mean±SD)***	**Reference**	**Risk estimate, 95% CI**	**Adjustment**	**RoB**
I.	**Outcome: Contracting SARS-CoV-2**													
Blanch-Rubio	Spain	-	1 Mar to 3 May 20	Cross-sectional	Secondary care	Patients with OP, OA or FM; attended outpatient clinic in previous 6 months	Physician diagnosis	Physician diagnosis	109/2,102	Age, c (65.7±13.2]) Female sex (88/1,693)	Age, c (66.5±13.3) Male sex	RR 0.99, 0.98 to 1.01 RR 1.11, 0.7 to 1.76	Age, sex, DM, CLD, CVD, CKD, cancer, medication	
Fike	US	Observational RMD cohort at NIAMS	1 Apr to 15 Oct 20	Prospective	Secondary care	Latino patients with RMD; all cohort participants were contacted before 1 Jun 20 and those who attended outpatient clinic in study period were included in analysis	Physician diagnosis	PCR+ or serology+	32/178	**BMI >30.35 (20/71)**	BMI <30.35	**OR 3.37, 1.5 to 7.7**	Age>39.5, BMI>30.4, sex, HT, DM, CLD	
II.	**Outcome: Hospitalisation for COVID-19**													
Boteanu (POS1260)	Spain	REUMA-COVID SORCOM	1 Mar to 10 Nov 20	Retrospective, registry	Secondary care	Patients with inflammatory RMD and COVID-19; NR	Physician diagnosis	PCR+ or serology+ or typiscal CT imaging or highly suspected based on clinical symptoms	174/412	**Age >62 (NR)** **Male sex (NR)**	Age 18-62 Female sex	**OR 5.5, 3.1 to 10.1** **OR 1.8, 1.04 to 3.2**	Age, sex, presence of comorbidities, obesity, CVD, RMD type, GC use, HCQ use, bDMARD use, disease duration	
FAI consortium	France	French COVID-19 registry	Until 18 May 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	256/694	Age, c (65.4±16.1) **Female sex (153/462)** **BMI, c (NR)**	Age, c (50.6±13.9) Male sex BMI, c (NR)	OR 1.05, 1.04 to 1.07 **OR 0.65, 0.43 to 0.99** **OR 1.06, 1.02 to 1.10**	Age, sex, CVD, DM, BMI, HT, CKD, RMD type, GC, NSAIDs, colchicine, MMF, TNFi	Sens+
Fernandez-Gutierrez	Spain	HCSC COVID-19 cohort	1 Mar to 15 Apr 20	Retrospective	Secondary care	Patients with inflammatory RMD and COVID-19; all patients attending outpatient clinic Mar 19 to Mar 20	ICD-10	PCR+ or physician diagnosis	54/3,951	**Age >75 (23/NR)** **Female sex (32/2,857)**	Age ≤75 Male sex	**HR 1.8, 1.03 to 3.17** **HR 0.55, 0.3 to 0.95**	Age, sex, RMD type, comorbidities, GC use, csDMARD use	
Freites Nuñez	Spain	-	1 Mar to 24 Apr 20	Prospective	Secondary care	Patients with inflammatory RMD and COVID-19; attended outpatient clinic in study period	ICD-10	PCR+ or physician diagnosis	54/123	**Age, c (68.8±15.8)** Female sex (32/86)	Age, c (52.9±9.6) Male sex	**OR 1.08, 1.04 to 1.13** OR 0.45, 0.15 to 1.29	Age, sex, comorbidity	
Gianfrancesco (*Association*)	US	GRA COVID-19	24 Mar to 26 Aug 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	Typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	445/1,235	**Afro American (139/273)** **Latino (109/295)** **Asian (17/39)** Other/mixed race (9/27)**	White White White White	**OR 2.74, 1.90 to 3.95** **OR 1.71, 1.18 to 2.49** **OR 2.69, 1.16 to 6.24** OR 2.59, 0.97 to 6.90**	Age, sex, RMD, comorbidities, smoking, medication use, GC use, disease activity	
Gianfrancesco (*Characteristics*)	World	GRA COVID-19	24 Mar to 20 Apr 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	Typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	277/600	**Age >65 (119/170)** Female sex (185/423)	Age ≤65 Male sex	**OR 2.56, 1.62 to 4.04** OR 0.83, 0.54 to 1.28	Age, sex, RMD, comorbidities, smoking, medication use, GC use, disease activity	Sens+
Mena Vázquez *(Hospitalization and)*	Spain	-	14 Mar to 14 Apr 20	Case-control	Secondary care	Patients with inflammatory RMD and COVID-19 (cases) and non-RMD patients with COVID-19 (controls); hospital records	Physician diagnosis	PCR+ or clinical symptoms and typical imaging	92/156	**Age, c (60.9±14.2)**	Age, c (60.8±14.8)	**OR 1.16, 1.10 to 1.20**	Age, sex, PCR date, HT, DM, GC use	
III.	**Outcome: COVID-19 related death**													
Alpizar-Rodriguez (POS1242)	Mexico	Mexican GRA COVID-19 registry	17 Apr to 30 Oct 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	43/323	**Age >65 (18/62)** Female sex (33/268)	Age ≤65 Male sex	**OR 3.9, 1.9 to 8.3** OR 0.5, 0.2 to 1.3	Age, sex, RMD type, comorbidities, disease activity, GC use, csDMARD use, RTX use	
Gianfrancesco (*Association*)	US	GRA COVID-19	24 Mar to 26 Aug 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	Typical imaging or symptoms after contact with case or highly suspected based	85/1,323	Afro American (16/273) Latino (21/295) Asian (4/39)** Other/mixed race (2/27)**	White White White White	OR 1.39, 0.69 to 2.79 OR 1.67, 0.81 to 3.41 OR 2.67, 0.58 to 12.16** OR 2.49, 0.49 to 12.65**	Age, sex, RMD, comorbidities, smoking, medication use, GC use, disease activity	

								on clinical symptoms						
Mena Vázquez *(Hospitalization and)*	Spain	-	14 Mar to 14 Apr 20	Case-control	Secondary care	Patients with inflammatory RMD and COVID-19 (cases) and non-RMD patients with COVID-19 (controls); hospital records	Physician diagnosis	PCR+ or clinical symptoms and typical imaging	9/156	**Age, c (60.9±14.2)**	Age, c (60.8±14.8)	**OR 1.11, 1.02 to 1.25**	Age, sex, PCR date, HT, DM	
Strangfeld	World	GRA COVID-19	24 Mar to 1 Jul 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	All RMD 384/3,705	**Age 66-75 (109/644)** **Age >75 (157/496)** **Male sex (161/1,188)**	Age ≤65 Age ≤65 Female sex	**OR 3.00, 2.13 to 4.22** **OR 6.18, 4.47 to 8.53** **OR 1.46, 1.11 to 1.91**	Age, sex, HT, CVD, CLD, CKD, DM, smoking, RMD type, disease activity, RMD treatment, GC	Sens+
									IJD 211/2,348	**Age 66-75 (71/426)** **Age >75 (85/265)** Male sex (82/788)	Age ≤65 Age ≤65 Female sex	**OR 3.65, 2.55 to 5.15** **OR 8.21, 5.54 to 12.18** OR 1.31, 0.95 to 1.80		
									CTD or vasculitis 147/1,157	**Age 66-75 (33/187)** **Age >75 (58/191)** Male sex (63/296)	Age ≤65 Age ≤65 Female sex	**OR 2.29, 1.34 to 3.93** **OR 4.08, 2.27 to 7.36** OR 1.66, 0.96 to 2.86		
IV.	**Outcome: 'severe COVID-19'**													
FAI consortium	France	French COVID-19 registry	Until 18 May 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	87/694 (ICU or death)	**Age, c (72.4±13.8)** **Female sex (44/462)** **BMI, c (NR)**	Age, c (NR) Male sex BMI, c (NR)	**OR 1.08, 1.05 to 1.10** **OR 0.45, 0.25 to 0.80** **OR 1.07, 1.02 to 1.12**	Age, sex, interstitial lung disease, DM, BMI, HT, CKD, RMD type, GC, MMF, RTX	Sens+
Gianfrancesco (*Association*)	US	GRA COVID-19	24 Mar to 26 Aug 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	Typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	90/340 (IMV)	Afro American (40/139) **Latino (37/109)** Asian (5/17)** Other/mixed race (1/9)**	White White White White	OR 1.54, 0.89 to 2.68 **OR 3.25, 1.75 to 6.05** OR 1.73, 0.45 to 6.63** OR 1.43, 0.33 to 6.15**	Age, sex, RMD, comorbidities, smoking, medication use, GC use, disease activity	
Pablos (*Clinical outcomes*)	Spain	RIER network	Until 17 Apr 20	Retrospective	Secondary care	Patients with inflammatory RMD and COVID-19; data from electronic health records	Physician diagnosis	PCR+	72/228 (ICU or intubation or serious complications or death)	**Age >60 (NR/127)** **Male sex (NR/ 87)**	Age <60 Female sex	**OR 4.83, 2.78 to 8.37** **OR 1.93, 1.21 to 3.07**	Age, sex, comorbidity, medication, RMD type, RMD medication, COVID-19 therapy	
Ugarte-Gil (OP0286)	World	GRA COVID-19	24 Mar 20 to 8 Jan 21	Cross-sectional, registry	Secondary care	Patients with SLE and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	116/1,069 (hospitalised + non-invasive ventilation) 25/1,079 (hospitalised + IMV/ECMO) 78/1,069 (death)†	**Age, c (NR)** **Male sex (20/1,069)** White (NR)	Age, c Female sex non-White	**OR 1.03, 1.01 to 1.04** **OR 1.93, 1.21 to 3.08** OR 1.47, 0.87 to 2.50	Age, sex, race, region, calender time, DMARD use, GC use and dosage, comorbidity count, CVD, CKD, disease activity	

*n/N: number of patients with outcome / number of patients exposed to risk factor or mean±SD (reported for continuous risk factor). **Indicates that there were less than 10 cases with the risk factor and the outcome. †Risk estimates of progression to worse COVID-19 outcome on 4-point ordinal scale. 'Sens+' indicates that a sensitivity analysis was performed, and results were consistent. Statistically significant associations are indicated in **bold**. Colours denote overall RoB assessment of each study (green: low risk of bias, orange: unclear risk of bias, red: high risk of bias).

BMI, body mass index; c, continuous; CKD, chronic kidney disease; CLD, chronic lung disease; CT, computerized tomography; CVD, cardiovascular disease; DM, diabetes mellitus; (ts/b)DMARD, (targeted synthetic/biologic) disease-modifying anti-rheumatic drug; ECMO, extracorporeal membrane oxygenation; FM, fibromyalgia; GC, glucocorticoid; HT, hypertension; IJD, inflammatory joint disease; IMV, invasive mechanical ventilation; MMF, mycophenolate mofetil; NR, not reported; NSAID, non-steroidal anti-inflammatory drug; OA, osteoarthritis; OP, osteoporosis; OR, odds ratio; PCR, polymerase chain reaction; RMD, rheumatic and musculoskeletal diseases; RoB, risk of bias; RR, risk ratio; RTX, rituximab; TNFi, tumor necrosis factor alpha inhibitor; US, United States.

Supplementary Table 9: Comorbidities as risk factor for developing (severe) COVID-19

Supplementary Table 8. Studies with data on comorbidities as risk factor for developing (severe) COVID-19 in patients with RMDs														
First author	**Country**	**Cohort**	**Study period**	**Study type**	**Setting**	**Study population; recruitment**	**Case definition RMD**	**Case definition COVID-19**	**Total n/N with outcome**	**Risk factor (n/N)***	**Reference**	**Risk estimate, 95% CI**	**Adjustment**	**RoB**
I.	**Outcome: Contracting SARS-CoV-2**													
Blanch-Rubio	Spain	-	1 Mar to 3 May 20	Cross-sectional	Secondary care	Patients with OP, OA or FM; attended outpatient clinic in previous 6 months	Physician diagnosis	Physician diagnosis	109/2,102	CVD (28/314) DM (19/264) CLD (25/315) CKD (10/114) Cancer (6/121)**	No CVD No DM No CLD No CKD No cancer	**RR 1.86, 1.19 to 2.91** RR 1.19, 0.7 to 2.03 RR 1.34, 0.73 to 2.46 RR 1.56, 0.8 to 3.03 RR 1.06, 0.45 to 2.47**	Age, sex, DM, CLD, CVD, CKD, cancer, gabapentin, pregabalin, opioids, duloxetine, amitriptyline, ACE2 inhibitors, ARBs, denosumab, bisphosphonates, calcium, vitamin D, thiazide diuretics, inhaled glucocorticoids, chronic NSAIDs	
II.	**Outcome: Hospitalisation for COVID-19**													
Boteanu (POS1260)	Spain	REUMA-COVID SORCOM	1 Mar to 10 Nov 20	Retrospective, registry	Secondary care	Patients with inflammatory RMD and COVID-19; NR	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	174/412	≥1 comorbidity (NR) Obesity (NR) **CVD (NR)**	No comorbidity No obesity No CVD	OR 1.4, 0.6 to 3.3 OR 1.9, 0.7 to 4.9 **OR 2.1, 1.2 to 3.8**	Age, sex, presence of comorbidities, obesity, CVD, RMD type, GC use, HCQ use, bDMARD use, disease duration	
FAI consortium	France	French COVID-19 registry	Until 18 May 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	256/694	**DM (50/70)**	No DM	**OR 4.33, 2.07 to 9.07**	Age, sex, CVD, DM, BMI, HT, CKD, RMD type, GC, NSAIDs, colchicine, MMF, TNFi	Sens+
Fernandez-Gutierrez	Spain	HCSC COVID-19 cohort	1 Mar to 15 Apr 20	Retrospective	Secondary care	Inflammatory RMD patients with COVID-19; all patients followed at outpatient clinic Mar 19 to Mar 20	ICD-10	PCR+ or physician diagnosis	54/3,951	**≥1 comorbidity (NR)**	No comorbidity	**HR 2.23, 1.2 to 3.9**	Age, sex, RMD type, comorbidities, GC use, csDMARD use	
Freites Nuñez	Spain	-	1 Mar to 24 Apr 20	Prospective	Secondary care	Patients with inflammatory RMD and COVID-19; attended outpatient clinic in study period	ICD-10	PCR+ or physician diagnosis	54/123	≥1 comorbidity (NR)	No comorbidity	OR 1.82, 0.69 to 4.80	Age, sex, comorbidity	
Gianfrancesco (*Characteristics*)	World	GRA COVID-19	24 Mar to 20 Apr 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	Typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	277/600	**HT or CVD (136/218)** **CLD (83/127)** **DM (48/69)** **CKD (33/40)**	No HT and CVD No CLD No DM No CKD	**OR 1.86, 1.23 to 2.81** **OR 2.48, 1.55 to 3.98** **OR 2.61, 1.39 to 4.88** **OR 3.02, 1.21 to 7.54**	Age, sex, RMD, comorbidities, smoking, medication use, GC use, disease activity	Sens+
Haberman (*COVID-19 in*)	US	WARCOV	3 Mar to 4 May 20	Prospective	Secondary care	Patients with RA and SpA and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or highly suspected based on CDC guidelines	27/103	HT (13/24) Asthma (3/15)** Heart failure (2/4)** **COPD (4/5)**** DM (5/10)**	No HT No asthma No heart failure No COPD No DM	OR 2.86, 0.94 to 8.69 OR 0.57, 0.12 to 2.82** OR 0.71, 0.06 to 6.46** **OR 15.1, 1.18 to 192.6**** OR 0.99, 0.21 to 4.77**	Age, sex, BMI	
Mena Vázquez *(Hospitalization and)*	Spain	-	14 Mar to 14 Apr 20	Case-control	Secondary care	Patients with inflammatory RMD and COVID-19 (cases) and non-RMD patients with COVID-19 (controls); hospital records	Physician diagnosis	PCR+ or clinical symptoms and typical imaging	92/156	**HT (32/78)**	No HT	**OR 3.90, 1.50 to 6.70**	Age, sex, PCR date, HT, DM, GC use	
III.	**Outcome: COVID-19 related death**													
Alpizar-Rodriguez (POS1242)	Mexico	Mexican GRA COVID-19 registry	17 Apr to 30 Oct 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	43/323	**DM type 2 (13/49)** **CKD (6/17)****	No DM No CKD	**OR 2.4, 1.1 to 5.4** **OR 3.4, 1.1 to 10.4****	Age, sex, RMD type, comorbidities, disease activity, GC use, csDMARD use, RTX use	

Juge (POS1227)	France	French COVID-19 registry	18 Mar to 26 June 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	68/897	**Pre-existing ILD (10/27)**	No ILD	**OR 12.3, 3.8 to 39.2**	Age, sex, BMI, diabetes	
Strangfeld	World	GRA COVID-19	24 Mar to 1 Jul 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	All RMD 384/3,705	HT or CVD alone (155/1,150) **HT and CVD (89/301)** **CLD (136/721)** CKD (76/259) DM (96/508)	No HT and CVD No HT or CVD No CLD No CKD No DM	OR 1.19, 0.89 to 1.59 **OR 1.89, 1.31 to 2.73** **OR 1.68, 1.26 to 2.25** OR 1.67, 0.99 to 2.80 OR 1.38, 0.88 to 2.17	Age, sex, HT, CVD, CLD, CKD, DM, smoking, RMD type, disease activity, RMD treatment, GC	Sens+
									IJD 211/2,348	HT or CVD alone (79/690) **HT and CVD (53/168)** **CLD (76/406)** CKD (27/111) DM (55/313)	No HT and CVD No HT or CVD No CLD No CKD No DM	OR 1.04, 0.74 to 1.46 **OR 2.29, 1.25 to 4.23** **OR 1.52, 1.04 to 2.21** OR 1.09, 0.54 to 2.21 OR 1.31, 0.95 to 1.79		
									CTD or vasculitis 147/1,157	**HT or CVD alone (69/406)** HT and CVD (28/106) **CLD (54/285)** **CKD (41/124)** DM (32/154)	No HT and CVD No HT or CVD No CLD No CKD No DM	**OR 1.56, 1.06 to 2.29** OR 1.57, 0.78 to 3.16 **OR 2.05, 1.47 to 2.85** **OR 2.30, 1.37 to 3.88** OR 1.39, 0.64 to 3.00		
IV.	**Outcome: 'severe COVID-19'**													
Esatoglu	Turkey	Turkish COVID-19 registry	20 Apr to 16 Jun 20	Cross-sectional	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging and clinical symtpoms	23/165 (ICU or death) †	**None** **CKD (NR/6)** CVA (NR/5) **Obesity (NR/10)** CVD (NR/15) **CLD (NR/23)** Other immune disorder (NR) HT (NR/51) DM (NR/17) Malignancy (NR/6)	Any comorbidity No CKD No CVA No obesity No CVD No CLD No immunedisorder No HT No DM No malignancy	**OR 0.41, 0.2 to 0.8** **OR 12.87, 2.25 to 103.5** OR 4.94, 0.96 to 29.12 **OR 3.7, 1.01 to 13.87** OR 2.49, 0.81 to 7.83 **OR 2.66, 1.08 to 6.61** OR 1.79, 0.38 to 8.39 OR 1.22, 0.55 to 2.71 OR 1.15, 0.4 to 3.28 OR 1.09, 0.26 to 4.48	Age, sex, smoking	
FAI consortium	France	French COVID-19 registry	Until 18 May 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	87/694 (ICU or death)	**HT (51/182)**	No HT	**OR 1.86, 1.01 to 3.42**	Age, sex, interstitial lung disease, DM, BMI, HT, CKD, RMD type, GC, MMF, RTX	Sens+
Juge (POS1227)	France	French COVID-19 registry	18 Mar to 26 June 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	NR/897 (ICU)	**Pre-existing ILD (22/27)**	No ILD	**OR 7.6, 2.9 to 20.2**	Age, sex, BMI, diabetes	
Pablos (*Clinical outcomes*)	Spain	RIER network	Until 17 Apr 20	Retrospective	Secondary care	Patients with inflammatory RMD and COVID-19; data from electronic health records	Physician diagnosis	PCR+	72/228 (ICU or intubation or serious complications or death)	Obesity (NR/71) DM (NR/46) Heart failure (NR)	No obesity No DM No heart failure	OR 1.47, 0.86 to 2.51 OR 0.82, 0.46 to 1.46 OR 1.57, 0.93 to 2.66	Age, sex, comorbidity, medication, RMD type, RMD medication, COVID-19 therapy	
Ugarte-Gil (OP0286)	World	GRA COVID-19	24 Mar 20 to 8 Jan 21	Cross-sectional, registry	Secondary care	Patients with SLE and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	116/1,069 (hospitalised + non-invasive ventilation) 25/1,079 (hospitalised + IMV/ECMO) 78/1,069 (death)†	Number of comorbidities **CKD (NR)** **CVD (NR)**	- No CKD No CVD	OR 1.39, 0.97 to 1.99 **OR 2.34, 1.48 to 3.70** **OR 1.93, 1.34 to 3.91**	Age, sex, race, region, calendar time, DMARD use, GC use and dosage, comorbidity count, CVD, CKD, DA	

*n/N: number of patients with outcome / number of patients exposed to risk factor. **Indicates that there were less than 10 cases with the risk factor and the outcome. †Risk estimates of progression to worse COVID-19 outcome on 4-point ordinal scale. 'Sens+' indicates that a sensitivity analysis was performed, and results were consistent. Statistically significant associations are indicated in **bold**. Colours denote overall RoB assessment of each study (green: low risk of bias, orange: unclear risk of bias, red: high risk of bias).

BMI, body mass index; c, continuous; CKD, chronic kidney disease; CLD, chronic lung disease; CT, computerized tomography; CVD, cardiovascular disease; CVA, cerebrovascular accident; DA, disease activity; DM, diabetes mellitus; (ts/b)DMARD, (targeted synthetic/biologic) disease-modifying anti-rheumatic drug; FM, fibromyalgia; GC, glucocorticoid; HT, hypertension; IJD, inflammatory joint disease; ILD, interstitial lung disease; MMF, mycophenolate mofetil; NR, not reported; NSAID, non-steroidal anti-inflammatory drug; OA, osteoarthritis; OP, osteoporosis; OR, odds ratio; PCR, polymerase chain reaction; RA, rheumatoid arthritis; RMD, rheumatic and musculoskeletal diseases; RoB, risk of bias; RR, risk ratio; RTX, rituximab; SpA, spondyloarthritis; TNFi, tumor necrosis factor alpha inhibitor; US, United States.

Supplementary Table 10: RMD type as risk factor for developing (severe) COVID-19

Supplementary Table 10. Studies with data on RMD type as risk factor for developing (severe) COVID-19														
First author	**Country**	**Cohort**	**Study period**	**Study type**	**Setting**	**Study population; recruitment**	**Case definition RMD**	**Case definition COVID-19**	**Total n/N with outcome**	**RMD type (n/N)***	**Reference**	**Risk estimate, 95% CI**	**Adjustment**	**RoB**
I.	**Outcome: Contracting SARS-CoV-2**													
England	US	Veterans Health Administration	1 Jan to 10 Dec 20	Retrospective, matched	Secondary care	Patients with RA and matched non-RA controls; data from administrative databases	Diagnostic code	PCR+	1,503/67,772	**RA (856/33,886)**	Non-RA controls	**HR 1.25, 1.13 to 1.39**	Age, sex, center, race, ethnicity, smoking, comorbidities, insurance, rural residency, prior hospitalisations, county-level COVID-19 incidence rates	Sens+
Topless	UK	UK Biobank	Until 24 Aug 20	Retrospective, registry	Population-based	Persons from the general population; data from UK Biobank data portal	Combination of ICD-10, self-report and (gout) medication use	Serology+ or ICD-10 for confirmed or probable COVID-19 in hospital/death records	2,118/471,021	Gout (117/12,988) **RA (61/5,348)**	No gout No RA	OR 1.01, 0.83 to 1.24 **OR 1.34, 1.02 to 1.77**	Age, sex, ethnicity, SES, BMI, smoking, comorbidities	
Vila-Córcoles	Spain	-	1 Mar to 30 Apr 20	Retrospective	Population-based	All persons aged ≥50 in area with active clinical history; data from hospital records	ICD-10 codes of RA and SLE	PCR+	201/77,671	RA or SLE (1/860)	No RA or SLE	OR 0.49, 0.07 to 3.61	Age, sex, previous vaccinations, comorbidities	
Zhong	China	-	20 Mar to 30 Mar 20	Cross-sectional	Population-based	Patients with inflammatory RMD with COVID-19 with ≥1 family member with COVID-19 and non-RMD family member controls; data from electronic health care records and telephone contact with family members	Unspecified diagnostic code, confirmed by self-report	Self-reported PCR+	55/126	**Inflammatory RMD (27/43)**	Non-RMD family member	**OR 2.68, 1.14 to 6.27**	Age, sex, smoking, comorbidities (unspecified)	
II.	**Outcome: Hospitalisation for COVID-19**													
Boteanu (POS1260)	Spain	REUMA-COVID SORCOM	1 Mar to 10 Nov 20	Retrospective, registry	Secondary care	Patients with inflammatory RMD and COVID-19; NR	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	174/412	Autoinflammatory disease (NR) CTD	Inflammatory arthritis Inflammatory arthritis	OR 1.06, 0.1 to 9.1 OR 0.7, 0.3 to 1.3	Age, sex, presence of comorbidities, obesity, CVD, RMD type, GC use, HCQ use, bDMARD use, disease duration	
D'Silva	US	TriNetX database	20 Jan to 15 Aug 20	Retrospective, matched (age, sex, race, BMI, comorbidities)	Secondary care	Patients with inflammatory RMD and COVID-19 and non-RMD controls with COVID-19; data from electronic health records	ICD-10	ICD-10	1,195/4,748	Inflammatory RMD (616/2,374)	Non-RMD controls	RR 1.06, 0.96 to 1.17	Age, sex, race, BMI, comorbidities, prior hospitalization	
FAI consortium	France	French COVID-19 registry	Until 18 May 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	256/694	Autoinflammatory disease (7/12)** Vasculitis (44/65) Systemic autoimmune disease (49/122)	Inflammatory arthritis Inflammatory arthritis Inflammatory arthritis	**OR 6.37, 1.45 to 28.05**** OR 1.60, 0.76 to 3.31 OR 1.51, 0.87 to 2.62	Age, sex, CVD, DM, BMI, HT, CKD, RMD type, GC, NSAIDs, colchicine, MMF, TNFi	Sens+
Fernandez-Gutierrez	Spain	HCSC COVID-19 cohort	1 Mar to 15 Apr 20	Retrospective	Secondary care	Patients with inflammatory RMD and COVID-19; all patients followed at outpatient clinic Mar 19 to Mar 20	ICD-10	PCR+ or physician diagnosis (76% tested)	54/3,951	Systemic autoimmune disease (NR)	Inflammatory arthritis	HR 1.23, 0.7 to 2.15	Age, sex, RMD type, comorbidities, GC use, csDMARD use	
Freites Nuñez	Spain	-	1 Mar to 24 Apr 20	Prospective	Secondary care	Patients with inflammatory RMD and COVID-19; attended outpatient clinic in study period	ICD-10	PCR+ or physician diagnosis	54/123	**Systemic autoimmune disease (NR)**	Inflammatory arthritis	**OR 3.55, 1.30 to 9.67**	Age, sex, comorbidity	
Gianfrancesco (*Characteristics*)	World	GRA COVID-19	24 Mar to 20 Apr 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	Typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	277/600	SLE (48/85) PsA (22/74) SpA (16/48) Vasculitis (24/39) Other RMD (63/129)	RA RA RA RA RA	OR 1.80, 0.99 to 3.29 OR 0.94, 0.48 to 1.83 OR 1.11, 0.50 to 2.42 OR 1.56, 0.66 to 3.68 OR 0.94, 0.55 to 1.62	Age, sex, RMD, comorbidities, smoking, medication use, GC use, disease activity	Sens+
Pakhchanian	US	TriNetX database	NR	Retrospective, matched	Secondary care	Patients with dermatopolymyositis and COVID-19 and controls with COVID-19	ICD-10	ICD-10	NR/354	Dermatopolymyositis (NR/177)	No dermatopolymyositis	OR 0.97, 0.63 to 1.49	Demographics, comorbitidies	

Perez-Sancristobal (POS1251)	Spain	HCSC COVID-19 cohort	1 Mar to 20 May 20	Retrospective	Secondary care	RMD patients with COVID-19; patients followed at outpatient clinic	ICD-10	PCR+ or physician diagnosis	146/406	**Autoimmune RMD (NR/162)** **IJD (NR/106)** **Non-autoimmune RMD (NR/244)**	Non-autoimmune RMD Systemic autoimmune RMD Systemic autoimmune RMD	**OR 1.75, 1.04 to 2.95** **OR 0.33, 0.14 to 0.76** **OR 0.28, 0.13 to 0.59**	Age, sex, comorbidities	
Serling-Boyd	US	-	30 Jan to 18 Aug 20	Prospective, matched (age, sex, PCR date)	Secondary care	Patients with inflammatory RMD and COVID-19 and non-RMD controls with COVID-19; data from electronic health records	ICD-9 and ICD-10	PCR+	353/831	Inflammatory RMD (58/143)	Non-RMD controls	HR 0.87, 0.68 to 1.11	Age, sex, PCR date, race, smoking, Charlson comorbidity index	Sens+
III.	**Outcome: COVID-19 related death**													
D'Silva	US	TriNetX database	20 Jan to 15 Aug 20	Retrospective, matched (age, sex, race, BMI, comorbidities)	Secondary care	Patients with inflammatory RMD and COVID-19 and non-RMD controls with COVID-19; data from electronic health records	ICD-10	ICD-10	172/4,748	Inflammatory RMD (93/2,374)	Non-RMD controls	RR 1.18, 0.88 to 1.58	Age, sex, race, BMI, comorbidities, prior hospitalization	
Freites (POS1253)	Spain	HCSC COVID-19 cohort	1 Mar to 20 May 20	Retrospective	Secondary care	RMD patients with COVID-19; patients followed at outpatient clinic	ICD-10	PCR+ or physician diagnosis	45/406	Inflammatory RMD (NR/162) IJD (NR/106) Non-inflammatory RMD (NR/244)	Non-inflammatory RMD Systemic autoimmune RMD Systemic autoimmune RMD	HR 1.12, 0.6 to 2.02 HR 1.5, 0.6 to 3.6 HR 1.1, 0.5 to 2.5	Age, sex, comorbidities	
Hsu (POS1174)	US	-	3 Jan to 7 July 20	Retrospective, matched	Secondary care	Patients with inflammatory RMD hospitalised for COVID-19 and non-RMD controls hospitalised for COVID-19; hospital records	NR (likely hospital records)	PCR+	49/279	Inflammatory RMD (12/57)	Non-RMD controls	OR 1.32, 0.61 to 2.88	Age, sex, PCR date, race, smoking, BMI, comorbidities	
Pakhchanian	US	TriNetX database	NR	Retrospective, matched	Secondary care	Patients with dermatopolymyositis and COVID-19 and controls with COVID-19	ICD-10	ICD-10	NR/354	Dermatopolymyositis (NR/177)	No dermatopolymyositis	OR 1.2, 0.53 to 2.71	Demographics, comorbitidies	
Serling-Boyd	US	-	30 Jan to 18 Aug 20	Prospective, matched (age, sex, PCR date)	Secondary care	Patients with inflammatory RMD and COVID-19 and non-RMD controls with COVID-19; data from electronic health records	ICD-9 and ICD-10	PCR+	60/831	Inflammatory RMD (12/143)	Non-RMD controls	HR 1.02, 0.53 to 1.95	Age, sex, PCR date, race, smoking, Charlson comorbidity index	Sens+
Strangfeld	World	GRA COVID-19	24 Mar to 1 Jul 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	All RMD 384/3,705	SLE (36/391) Vasculitis (67/325) **Other CTD (53/473)** PsA (19/429) SpA (15/423) Other inflammatory arthritis (10/109) **Other rheumatic disease (24/229)**	RA RA RA RA RA RA RA	OR 1.2, 0.70 to 2.04 OR 0.8, 0.60 to 1.08 **OR 0.75, 0.58 to 0.97** OR 0.75, 0.53 to 1.07 OR 0.72, 0.34 to 1.54 OR 0.79, 0.46 to 1.34 **OR 0.51, 0.35 to 0.73**	Age, sex, HT, CVD, CLD, CKD, DM, smoking, RMD type, disease activity, RMD treatment, GC	Sens+
									IJD 211/2,348	PsA (19/437) SpA (15/424) Other inflammatory arthritis (11/114)	RA RA RA	OR 0.82, 0.55 to 1.22 OR 0.82, 0.40 to 1.69 OR 0.76, 0.43 to 1.36		
									CTD or vasculitis 147/1,157	Vasculitis (64/318) Other CTD (51/461)	SLE SLE	OR 0.81, 0.49 to 1.33 OR 0.78, 0.39 to 1.54		
Topless	UK	UK Biobank	Until 24 Aug 20	Retrospective, registry	Population-based	Patients with COVID-19; data from UK Biobank data portal	Combination of ICD-10, self-report and (gout) medication use	Serology+ or ICD-10 for confirmed or probable COVID-19 in hospital/death records	457/1,602	Gout (42/73) RA (23/38)	No gout No RA	OR 1.26, 0.81 to 1.95 OR 1.63, 0.89 to 2.96	Age, sex, ethnicity, SES, BMI, smoking, comorbidities	
IV.	**Outcome: 'severe COVID-19'**													
D'Silva	US	TriNetX database	20 Jan to 15 Aug 20	Retrospective, matched (age, sex, race, BMI, comorbidities)	Secondary care	Patients with inflammatory RMD and COVID-19 and non-RMD controls with COVID-19; data from electronic health records	ICD-10	ICD-10	275/4,748 (ICU)	Inflammatory RMD (141/2,374)	Non-RMD controls	RR 1.05, 0.84 to 1.32	Age, sex, race, BMI, comorbidities, prior hospitalization	
									162/4,748 (IMV)	Inflammatory RMD (77/2,374)	Non-RMD controls	RR 0.91, 0.67 to 1.23		
									403/4,748 (ICU or IMV or death)	Inflammatory RMD (212/2,374)	Non-RMD controls	RR 1.11, 0.92 to 1.34		
England	US	Veterans Health Administration	1 Jan to 10 Dec 20	Retrospective, matched	Secondary care	Patients with RA and matched non-RA controls; data from administrative databases	Diagnostic code	PCR+	388/67,772 (hospitalisation or death)	**RA (235/33,886)**	Non-RA controls	**HR 1.35, 1.10 to 1.66**	Age, sex, center, race, ethnicity, smoking, comorbidities, insurance, rural residency, prior hospitalisations, county-level COVID-19 incidence rates	
Esatoglu	Turkey	Turkish COVID-19 registry	20 Apr to 16 Jun 20	Cross-sectional	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging and clinical symtpoms	23/165 (ICU or death)†	FMF (NR/14) Behçet syndrome (NR/15) CTD (NR/29) RA (NR/60) SpA (NR/42)	No FMF No Behçet syndrome No CTD No RA No SpA	OR 2.3, 0.74 to 7.25 OR 1.47, 0.49 to 4.42 OR 0.95, 0.37 to 2.41 OR 0.81, 0.4 to 1.66 OR 0.78, 0.38 to 1.58	Age, sex, comorbidity	
Hsu (POS1174)	US	-	3 Jan to 7 July 20	Retrospective, matched	Secondary care	Patients with inflammatory RMD hospitalised for COVID-19 and non-RMD	NR (likely hospital records)	PCR+	99/279 (ICU)	**Inflammatory RMD (29/57)**	Non-RMD controls	**OR 1.87, 1.03 to 3.40**	Age, sex, PCR date, race, smoking, BMI, comorbidities	
									66/279 (IMV)	**Inflammatory RMD (22/57)**	Non-RMD controls	**OR 2.46, 1.30 to 4.67**		

						controls hospitalised for COVID-19; hospital records								
Pablos (*Clinical outcomes*)	Spain	RIER network	Until 17 Apr 20	Retrospective, matched (age, sex, PCR date)	Secondary care	Patients with inflammatory RMD and COVID-19 and non-RMD controls with COVID-19; data from electronic health records	Physician diagnosis	PCR+	136/456 (ICU or intubation or serious complications or death)	Inflammatory RMD (72/228)	Non-RMD controls	RR 1.13, 0.84 to 1.49	Age, sex, PCR date	
									72/228 (ICU or intubation or serious complications or death)	**CTD (NR/92)**	Inflammatory arthritis	**RR 1.82, 1.00 to 3.30**	Age, sex, comorbidity, medication, RMD type, RMD medication, COVID-19 therapy	
Pakhchanian	US	TriNetX database	NR	Retrospective, matched	Secondary care	Patients with dermatopolymyositis and COVID-19 and non-dermatopolymyositis controls with COVID-19	ICD-10	ICD-10	NR/354 (IMV)	Dermatopolymyositis (NR/177)	No dermatopolymyositis	OR 0.97, 0.63 to 1.49	Demographics, comorbitidies	
									NR/354 (IMV or death)	Dermatopolymyositis (NR/177)	No dermatopolymyositis	OR 1.5, 0.69 to 3.25		
Serling-Boyd	US	-	30 Jan to 18 Aug 20	Prospective, matched (age, sex, PCR date)	Secondary care	Patients with inflammatory RMD and COVID-19 and non-RMD controls with COVID-19; data from electronic health records	ICD-9 and ICD-10	PCR+	124/831 (ICU)	Inflammatory RMD (28/143)	Non-RMD controls	HR 1.27, 0.86 to 1.86	Age, sex, PCR date, race, smoking, Charlson comorbidity index	Sens+
									85/831 (IMV)	Inflammatory RMD (22/143)	Non-RMD controls	HR 1.51, 0.93 to 2.44		

*n/N: number of patients with outcome / number of patients exposed to risk factor. **Indicates that there were less than 10 cases with the risk factor and the outcome. †Risk estimates of progression to worse COVID-19 outcome on 4-point ordinal scale. 'Sens+' indicates that a sensitivity analysis was performed, and results were consistent. Statistically significant associations are indicated in **bold**. Colours denote overall RoB assessment of each study (green: low risk of bias, orange: unclear risk of bias, red: high risk of bias).

BMI, body mass index; c, continuous; CKD, chronic kidney disease; CLD, chronic lung disease; CT, computerized tomography; (u)CTD, (undifferentiated) connective tissue disease;CVD, cardiovascular disease; DA, disease activity; DM, diabetes mellitus; (ts/b)DMARD, (targeted synthetic/biologic) disease-modifying anti-rheumatic drug; FM, fibromyalgia; FMF, familial Mediterranean fever; GC, glucocorticoid; HR, hazard ratio; HT, hypertension; ICU, intensive care unit; IJD, inflammatory joint disease; IMV, invasive mechanical ventilation; MMF, mycophenolate mofetil; NR, not reported; NSAID, non-steroidal anti-inflammatory drug; OA, osteoarthritis; OP, osteoporosis; OR, odds ratio; PCR, polymerase chain reaction; PsA, psoriatic arthritis; RA, rheumatoid arthritis; RMD, rheumatic and musculoskeletal diseases; RoB, risk of bias; RR, risk ratio; RTX, rituximab; SLE, systemic lupus erythematosus; SpA, spondyloarthritis; TNFi, tumor necrosis factor alpha inhibitor; US, United States.

Supplementary Table 11: Antirheumatic medication and disease activity as risk factors for developing (severe) COVID-19

Supplementary Table 11. Studies with data on antirheumatic medication and disease activity as risk factors for developing (severe) COVID-19 in patients with RMDs														
First author	**Country**	**Cohort**	**Study period**	**Study type**	**Setting**	**Study population; recruitment**	**Case definition RMD**	**Case definition COVID-19**	**Total n/N with outcome**	**Medication type (n/N)***	**Reference**	**Risk estimate, 95% CI**	**Adjustment**	**RoB**
I.	**Outcome: Contracting SARS-CoV-2**													
Blanch-Rubio	Spain	-	1 Mar to 3 May 20	Cross-sectional	Secondary care	Patients with OP, OA or FM; attended outpatient clinic in previous 6 months	Physician diagnosis	Physician diagnosis	109/2,102	Calcium (16/490) Vitamin D (62/1,303) Analgesics (66/1,220) Gabapentin (11/264) Pregabalin (12/146) Opioids (36/546) Other analgesics (53/959) Chronic NSAIDs (17/318) Denosumab (8/264)** Zolendronate IV (6/179)** Bisphosphonates oral (7/143)** Thiazide diuretics (14/262) Dual-action antidepressants (17/277) Duloxetine (9/207)** Tricyclic antidepressants (8/124)** Amitriptyline (8/102)** SSRI antidepressants (26/333) Inhaled GC (17/189) Antihypertensive drugs (36/646) ACE inhibitors (19/363) ARBs (17/290)	Non-user Non-user	RR 0.64, 0.37 to 1.11 RR 0.91, 0.62 to 1.34 RR 0.92, 0.61 to 1.38 RR 1.39, 0.75 to 2.58 RR 1.55, 0.86 to 2.79 RR 1.25, 0.85 to 1.83 RR 0.94, 0.64 to 1.37 RR 0.95, 0.58 to 1.55 RR 0.59, 0.28 to 1.23** RR 0.61, 0.27 to 1.38** RR 0.97, 0.46 to 2.06** RR 0.94, 0.53 to 1.66 RR 1.22, 0.72 to 2.08 RR 0.68, 0.34 to 1.34** RR 1.06, 0.54 to 2.08** RR 1.38, 0.7 to 2.71** RR 1.39, 0.9 to 2.14 RR 1.39, 0.7 to 2.74 RR 1.06, 0.7 to 1.6 RR 0.98, 0.58 to 1.65 RR 1.05, 0.62 to 1.76	Age, sex, DM, CLD, CVD, CKD, cancer, gabapentin, pregabalin, opioids, duloxetine, amitriptyline, ACE2 inhibitors, ARBs, denosumab, bisphosphonates, calcium, vitamin D, thiazide diuretics, inhaled glucocorticoids, chronic NSAIDs	
Chandan	UK	THIN database	30 Jan to 31 Jul 20	Retrospective, matched (propensity score)	Primary care	Patients with OA using NSAIDs and controls with OA using paracetamol/(dihydro)codeine; data from large primary care database	Read diagnostic code	Read diagnostic code	139/17,190	NSAID (63/8,595)	Paracetamol/ (dihydro)codeine	HR 0.79, 0.57 to 1.11	Age, sex, BMI, smoking, eGFR, blood pressure, DM, atrial fibrillation, cancer, vitamin D deficiency, CVD, dementia, liver disease, CLD, organ transplant, immunosuppressive drug use, psoriasis, neurological disorders	Sens+
Jung	Korea	Korean National Health Insurance Sharing COVID-19 database	Until 15 May 20	Retrospective	Population-based	Patients with RA and SLE; data from national insurance claims database	KCD-7	PCR+	46/2,066	HCQ (15/649)	Non-user	OR 1.13, 0.57 to 2.24	Age, sex, region, PCR date, HT, heart failure, CLD, peptic ulcer, bDMARD use, healthcare use, previous RA/SLE-related hospitalisation	Sens+
Kim	Korea	Korean National Health Insurance Sharing COVID-19 database	Jan to May 20	Retrospective, matched	Population-based	HCQ treated RMD patients and non-HCQ treated controls with RMD; data from national insurance claims database	ICD-10	PCR+	47/680	HCQ (24/340)	Non-user	OR 1.05, 0.58 to 1.89	Age, sex, RMD type, comorbidities	
II.	**Outcome: Hospitalisation for COVID-19**													
Alegiani	Italy	-	21 Feb to 10 Jun 20	Case-control	Population-based	csDMARD treated RMD patients with COVID-19 (cases) and csDMARD treated RMD patients without COVID-19 (controls); administrative claims databases	ICD-9	PCR+	1,275 cases and 12,734 controls	Antimalarial mono (225/1,275) other csDMARD (400/1,275)	MTX mono MTX mono	OR 0.83, 0.69 to 1.00 OR 1.15, 0.96 to 1.37	Age, sex, center, previous hospitalisation, comorbidities, medication use	Sens+
Avouac	France	French COVID-19 registry	15 Apr to 20 Nov 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	287/1,090 (non-intensive hospital treatment)	**RTX (20/63)**	Non-user	**OR 1.98, 1.08 to 3.63**	Inverse probability weighting	Sens+
									Duration of hospital stay in 424/1,090	**RTX (42/63 non-intensive hospital treatment and ICU admission)**		**median 13 vs 9 days (HR 0.62, 0.46 to 0.85**		

									hospitalised patients			for increased duration of hospital stay)		
Boteanu (POS1260)	Spain	REUMA-COVID SORCOM	1 Mar to 10 Nov 20	Retrospective, registry	Secondary care	Patients with inflammatory RMD and COVID-19; NR	Physician diagnosis	PCR+ or serology+ or typiscal CT imaging or highly suspected based on clinical symptoms	174/412	GC <10 mg/day (NR) GC >10 mg/day (NR) HCQ (NR) **TNFi (NR/89)** **IL-6i (NR)** RTX (NR/27)	No GC No GC No HCQ No bDMARD No bDMARD No bDMARD	OR 1.4, 0.8 to 2.6 OR 3.6, 0.7 to 18.9 OR 0.9, 0.4 to 1.9 **OR 0.3, 0.1 to 0.6** **OR 0.06, 0.006 to 0.6** OR 1.6, 0.5 to 4.5	Age, sex, presence of comorbidities, obesity, CVD, RMD type, GC use, HCQ use, bDMARD use, disease duration	
Bower	Sweden	-	May to Sep 20	Retrospective, registry, matched	Population-based	Inflammatory arthritis patients; data from national registries	Physician diagnosis	ICD-10	581/110,567	b/tsDMARDs (118/NR) TNFi (67/NR) RTX (24/NR) **JAKi (18/NR)** Abatacept (5/NR)** Tocilizumab (4/NR)**	csDMARD csDMARD csDMARD csDMARD csDMARD csDMARD	HR 1.08, 0.73 to 1.58 HR 1.05, 0.67 to 1.64 HR 1.03, 0.58 to 1.81 **HR 2.72, 1.14 to 6.47** HR 0.49, 0.15 to 1.59** not calculated**	Propensity score matched (age, sex, comorbidities, health-care utilisation, SES, disease activity, disease duration, RMD treatment), oral GC, csDMARD combination therapy	Sens+
Cordtz	Denmark	DANBIO	1 Mar to 12 Aug 20	Retrospective, registry	Population-based	ts/bDMARD treated RA, SpA, CTD or vasculitis patients; data from national registries	Physician diagnosis	ICD-10	69/58,052	TNFi (4/4110)** HCQ (3/2722)** GC (5/2411)**	Non-user Non-user Non-user	HR 0.78, 0.28 to 2.19** HR 0.76, 0.23 to 2.52** HR 1.22, 0.47 to 3.15**	Age, sex, CVD, DM, CLD, obesity, TNFi, HCQ, GC	Sens+
FAI consortium	France	French COVID-19 registry	Until 18 May 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	256/694	**GC (127/215)** **Colchicine (12/24)** **TNFi (32/202)**	Non-user Non-user Non-user	**OR 1.94, 1.24 to 3.05** **OR 3.34, 1.14 to 9.79** **OR 0.55, 0.32 to 0.95**	Age, sex, CVD, DM, BMI, HT, CKD, RMD type, GC, NSAIDs, colchicine, MMF, TNFi	Sens+
Fernandez-Gutierrez	Spain	HCSC COVID-19 cohort	1 Mar to 15 Apr 20	Retrospective	Secondary care	Patients with inflammatory RMD and COVID-19; all patients followed at outpatient clinic Mar 19 to Mar 20	ICD-10	PCR+ or physician diagnosis	54/3,951	TNFi (2/521)** Non-TNFi bDMARD (5/246)** GC (32/1,804)	No ts/bDMARDs No ts/bDMARDs No ts/bDMARDs	HR 0.32, 0.07 to 1.36** HR 1.57, 0.66 to 3.7** HR 1.48, 0.8 to 2.58	Age, sex, RMD type, comorbidities, GC use, csDMARD use	
Freites Nuñez	Spain	-	1 Mar to 24 Apr 20	Prospective	Secondary care	Patients with inflammatory RMD and COVID-19; attended outpatient clinic in study period	ICD-10	PCR+ or physician diagnosis	54/123	GC (32/61)	No GC	OR 1.97, 0.77 to 5.01	Age, sex, comorbidity	
Gianfrancesco (*Characteristics*)	Worldwide	GRA COVID-19	24 Mar to 20 Apr 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	Typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	277/600	NSAID (39/111) csDMARD mono (149/272) **b/tsDMARD mono (31/107)** b/tsDMARD + csDMARD (45/124) GC 1-9 mg/day (67/125) **GC >10 mg/day (43/64)**	No NSAID No DMARD No DMARD No DMARD No GC No GC	OR 0.64, 0.39 to 1.06 OR 1.23, 0.70 to 2.17 **OR 0.46, 0.22 to 0.93** OR 0.74, 0.37 to 1.46 OR 1.03, 0.64 to 1.66 **OR 2.05, 1.06 to 3.96**	Age, sex, RMD, comorbidities, smoking, medication use, GC use, disease activity	Sens+
Haberman (*COVID-19 in*)	USA	WARCOV	3 Mar to 4 May 20	Prospective	Secondary care	Patients with RA and SpA and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or highly suspected based on CDC guidelines	27/103	Any biologic (17/73) MTX (11/35) **Oral GC (10/13)** IL-17i (2/18)** **JAKi (7/11)**** TNFi (6/40)** **HCQ (6/13)**	Non-user Non-user Non-user Non-user Non-user Non-user Non-user	OR 1.07, 0.31 to 3.73 OR 0.77, 0.25 to 2.44 **OR 26.2, 3.82 to 180.2** OR 0.47, 0.08 to 2.74** **OR 10.23, 1.88 to 55.5**** OR 0.39, 0.11 to 1.43** **OR 4.79, 1.00 to 22.9**	Age, sex, BMI, comorbidities	
Madrid-García	Spain	HCSC COVID-19 cohort	1 Mar to 20 May 20	Retrospective	Secondary care	Patients with inflammatory RMD and COVID-19; all patients followed at outpatient clinic Mar 19 to Mar 20	ICD-10	PCR+	132/9,379	Colchicine (12/406)	No colchicine	HR 1.95, 0.88 to 4.29	Age, sex, RMD type, comorbidities, DMARD use	Sens+
Sbidian	France	French national health data system (SNDS)	15 Feb to 7 Jun 20	Retrospective, matched (age, department, insurance type), registry	Population-based	Patients with antimalarial drug prescription for inflammatory RMD and non-RMD controls without antimalarial drug use; data from national registries	ICD-10	ICD-10	323/210,562	Antimalarial drug (128/54,873)	Non-user	HR 1.15, 0.86 to 1.55	Age, sex, department, insurance type, extensive comorbidities, smoking, substance abuse, immunosuppressive medication, oral GC, NSAIDs	Sens+

Trefond	France	French COVID-19 registry	13 Apr to 29 Jul 20	Case-control nested in registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	77/262	HCQ (24/71)	No HCQ	OR 1.75, 0.86 to 3.56	Age, sex, comorbidity, immunosuppressive drug use, SARS-CoV-2 PCR positivity	
III.	**Outcome: COVID-19 related death**													
Alegiani	Italy	-	21 Feb to 10 Jun 20	Case-control	Population-based	csDMARD treated RMD patients with COVID-19 (cases) and csDMARD treated RMD patients without COVID-19 (controls); administrative claims databases	ICD-9	PCR+	369 cases and 3,684 controls	Antimalarial mono (81/369) **other csDMARD (112/369)**	MTX mono MTX mono	OR 1.19, 0.85-1.67 **OR 1.46, 1.02-2.08**	Age, sex, center, previous hospitalisation, comorbidities, medication use	Sens+
Alpizar-Rodriguez (POS1242)	Mexico	Mexican GRA COVID-19 registry	17 Apr to 30 Oct 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	43/323	**GC use (30/171)** **RTX (7/21)**	No GC No RTX	**OR 3.0, 1.4 to 6.5** **OR 4.9, 1.7 to 14.5**	Age, sex, RMD type, comorbidities, disease activity, GC use, csDMARD use, RTX use	
Avouac	France	French COVID-19 registry	15 Apr to 20 Nov 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	89/1,090	RTX (13/63)	No RTX	OR 1.32, 0.55-3.19	Inverse probability weighting	Propensity score matched: **OR 2.43, 1.10-8.43**; shorter time between first symptoms and RTX infusion in deceased (p=0.0086)
Bower	Sweden	-	May to Sep 20	Retrospective, registry, matched	Population-based	Patients with inflammatory arthritis; data from national registries	Physician diagnosis	ICD-10	161/110,567	b/tsDMARDs (24/NR) TNFi (7/NR)** RTX (9/NR)** JAKi (5/NR)** Tocilizumab (2/NR)** Abatacept (1/NR)**	csDMARD csDMARD csDMARD csDMARD csDMARD csDMARD	HR 1.26, 0.60 to 2.64 HR 1.03, 0.40 to 2.61** **HR 3.20, 1.19 to 8.57**** **HR 10.03, 2.35 to 42.8**** not calculated** not calculated**	Propensity score matched (age, sex, comorbidities, health-care utilisation, SES, disease activity, disease duration, RMD treatment), oral GC, csDMARD combination therapy	Sens+
Chandan	UK	THIN database	30 Jan to 31 Jul 20	Retrospective, matched (propensity score)	Primary care	Patients with OA using NSAIDs and controls with OA using paracetamol/(dihydro)codeine; data from large primary care database	Read diagnostic code	Read diagnostic code	150/17,190	NSAID (79/8,595)	Paracetamol/ (dihydro)codeine	HR 0.85, 0.61 to 1.20	Age, sex, BMI, smoking, eGFR, blood pressure, DM, atrial fibrillation, cancer, vitamin D deficiency, CVD, dementia, liver disease, CLD, organ transplant, immunosuppressive drug use, psoriasis,	Sens+

														neurological disorders	
Rentsch	UK	OpenSAFELY	1 Mar to 1 Sep 20	Prospective	Primary care	Patients with RA or SLE; data from electronic health records	Read diagnostic code	ICD-10	547/194,637	HCQ (70/30,569)	No HCQ	HR 1.03, 0.80 to 1.33	Age, sex, race, region, use of immunosuppressive drugs, smoking, NSAIDs, BMI, comorbidities, influenza vaccination	Sens+
Strangfeld	Worldwide	GRA COVID-19	24 Mar to 1 Jul 20	Cross-sectional, registry	Secondary care	Patients with RMD and COVID-19, reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	All RMD 384/3,705	**No DMARD (124/739)** Leflunomide (12/90) Antimalarials (27/426) **SSZ (33/144)** **Immunosuppressants (38/276)** TNFi (30/803) Abatacept (9/81)** **RTX (42/192)** Belimumab (1/27)** IL-6i (5/90)** IL-17i or (IL12/)IL-23i (1/115)** tsDMARDs (15/145) GC 1-10 mg/day (170/1,062) **GC >10 mg/day (49/226)** **Moderate/high DA (109/722)**	MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono No GC No GC Remission/low DA	**OR 2.11, 1.48 to 3.01** OR 1.56, 0.9 to 2.7 OR 0.99, 0.66 to 1.48 **OR 3.6, 1.66 to 7.78** **OR 2.22, 1.43 to 3.46** OR 0.85, 0.52 to 1.36 OR 1.20, 0.61 to 2.34** **OR 4.04, 2.32 to 7.03** OR 0.71, 0.19 to 2.68** OR 0.83, 0.38 to 1.84** OR 0.25, 0.03 to 2.04** OR 1.60, 0.91 to 2.8 OR 1.43, 0.98 to 2.09 **OR 1.69, 1.18 to 2.41** **OR 1.87, 1.27 to 2.77**	Age, sex, HT, CVD, CLD, CKD, DM, smoking, RMD type, disease activity, RMD treatment, GC	Sens+ Post-hoc (Schafer[48]): Effects of GC not significant in absence of moderate to severe DA; association DA and COVID-19 related death is independent of GC dose
									IJD 211/2,348	No DMARD (38/239) Leflunomide (10/83) Antimalarials (17/167) SSZ (31/137) TNFi (26/764) Abatacept (9/75)** RTX (22/90) IL-6i (1/68)** IL-17i or (IL12/)IL-23i (1/112)** tsDMARDs (15/142) GC 1-10 mg/day (89/567) GC >10 mg/day (12/60) Moderate/high DA (54/453)	MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono No GC No GC Remission/low DA	**OR 2.08, 1.38 to 3.14** OR 1.37, 0.69 to 2.73 OR 1.14, 0.65 to 2.00 **OR 3.40, 1.46 to 7.93** OR 0.77, 0.41 to 1.41 OR 1.30, 0.62 to 2.71** **OR 5.42, 2.77 to 10.61** OR 0.25, 0.03 to 2.43** OR 0.26, 0.03 to 2.06** OR 1.75, 0.99 to 3.12 OR 1.36, 0.76 to 2.45 OR 1.55, 0.67 to 3.57 **OR 1.60, 1.13 to 2.26**		
									CTD or vasculitis 147/1,157	No DMARD (67/353) Antimalarials (11/271) Immunosuppressants (32/247) TNFi (4/39) RTX (22/104) Belimumab (1/27)** IL-6i (4/23)** GC 1-10 mg/day (75/469) GC >10 mg/day (34/137) Moderate/high DA (51/230)	MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono MTX mono No GC No GC Remission/low DA	**OR 3.18, 1.61 to 6.27** OR 1.38, 0.48 to 4.02 **OR 2.44, 1.06 to 5.56** OR 2.00, 0.36 to 11.2 **OR 3.72, 1.21 to 11.48** OR 1.07, 0.21 to 5.37** OR 2.69, 0.88 to 8.19** **OR 1.69, 1.11 to 2.57** **OR 1.93, 1.11 to 3.36** **OR 2.45, 1.49 to 4.02**		
Trefond	France	French COVID-19 registry	13 Apr to 29 Jul 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	16/251	HCQ (4/68)	No HCQ	OR 1.18, 0.32 to 4.31	Age, sex, comorbidity, immunosuppressive drug use, SARS-CoV-2 PCR positivity	
Wong	UK	OpenSAFELY	1 Mar to 14 Jun 20	Prospective	Primary care	Patients with RA or OA	Read diagnostic code	ICD-10	2,573/1,708,781	**Any NSAID (NR/175,495)** Naproxen low dose (NR/175,495) Naproxen high dose (NR/175,495) COX-2 specific ((NR/175,495) Ibuprofen (NR/175,495)	Non-user Non-user Non-user Non-user Non-user	**HR 0.78, 0.64 to 0.94** HR 0.77, 0.53 to 1.11 HR 0.79, 0.58 to 1.07 HR 0.48, 0.22 to 1.08 HR 0.83, 0.56 to 1.25	Age, sex, obesity, extensive comorbidities, GD, DMARD, HCQ, statin, proton pump inhibitors,	Sens+

													influenza and pneumococcal vaccination	
IV.	**Outcome: 'severe COVID-19'**													
Avouac	France	French COVID-19 registry	15 Apr to 20 Nov 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	137/1,090 (ICU or death)	**RTX (22/63)**	No RTX	**OR 3.26, 1.66-6.40**	Inverse probability weighting	Sens+; shorter time between first symptoms and RTX infusion in severe COVID-19 (p=0.0002)
Bower	Sweden	-	May to Sep 20	Retrospective, registry, matched	Population-based	Patients with inflammatory arthritis; data from national registries	Physician diagnosis	ICD-10	45/110,567 (ICU)	b/tsDMARDs (12/NR) TNFi (8/NR)** RTX (2/NR)** Tocilizumab (0/NR)** Abatacept (1/NR)** JAKi (1/NR)**	csDMARD csDMARD csDMARD csDMARD csDMARD csDMARD	HR 1.74, 0.63 to 4.84 HR 2.05, 0.70 to 6.06** not calculated** not calculated** not calculated** not calculated**	Propensity score matched (age, sex, comorbidities, health-care utilisation, SES, disease activity, disease duration, RMD treatment), oral GC, csDMARD combination therapy	Sens+
Esatoglu	Turkey	Turkish COVID-19 registry	20 Apr to 16 Jun 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging and clinical symtpoms	92/165 (hospitalised) 49/165 (hospitalised with oxygen) 23/165 (ICU or death) †	No treatment (NR) **GC any dose (16/68, ICU/death)** **GC ≤7.5mg/day (11/49, ICU/death)** **GC >7.5mg/day (NR/18)** Colchicine (5/25, ICU/death)** RTX (1/NR, ICU/death)** Immunosuppressives (2/16, ICU/death)** HCQ (8/40, ICU/death)** non-RTX bDMARDs (2/36, ICU/death)** non-HCQ csDMARDs (9/79, ICU/death)**	Any treatment No GC No GC No GC Non-user Non-user Non-user Non-user Non-user Non-user	OR 0.59, 0.19 to 1.76 **OR 4.55, 1.66 to 12.85** **OR 3.78, 1.33 to 11.05** **OR 8.49, 2.43 to 30.89** OR 2.15, 0.88 to 5.34** OR 1.62, 0.38 to 6.73** OR 1.59, 0.53 to 4.77** OR 1.43, 0.67 to 3.07** OR 0.9, 0.39 to 2.03** OR 0.36, 0.17 to 0.75**	Age, sex, comorbidity, use of combination therapy	
FAI consortium	France	French COVID-19 registry	Until 18 May 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	87/694 (ICU or death)	GC (51/215) **MMF (3/16)** RTX (11/34)	No GC No MMF No RTX	**OR 1.97, 1.09 to 3.54** **OR 6.60, 1.47 to 29.62**** **OR 4.21, 1.61 to 10.98**	Age, sex, interstitial lung disease, DM, BMI, HT, CKD, RMD type, GC, MMF, RTX	Sens+
Pablos (*Clinical outcomes*)	Spain	RIER network	Until 17 Apr 20	Retrospective	Secondary care	Patients with inflammatory RMD and COVID-19; data from electronic health records	Physician diagnosis	PCR+	72/228 (ICU or intubation or serious complications or death)	GC (NR) Antivirals to treat COVID-19 (NR)	No GC No antivirals	OR 1.10, 0.60 to 2.01 OR 2.05, 1.30 to 3.23	Age, sex, comorbidity, medication, RMD type, RMD medication, COVID-19 therapy	
Sbidian	France	French national health data system (SNDS)	15 Feb to 7 Jun 20	Retrospective, matched (age, department, insurance type), registry	Population-based	Patients using antimalarials for inflammatory RMD and non-RMD controls not using antimalarials; data from national registries	ICD-10	ICD-10	47/210,562 (IMV or death)	Antimalarials (20/54,873)	Non-user	HR 0.66, 0.29 to 1.51	Age, sex, department, insurance type, extensive comorbidities, smoking, substance abuse, immunosuppressive medication, oral GC, NSAIDs	
Scirè	Italy	Italian COVID-19 registry (CONTROL-19)	26 Mar to 3 Jun 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+	49/232 (ICU or IMV or death)	b/tsDMARD mono (NR) csDMARD mono (NR) b/tsDMARD + csDMARD (NR) GC 1-9 mg/day (NR) GC ≥10 mg/day (NR)	No DMARD No DMARD No DMARD No GC No GC	OR 0.50, 0.13 to 1.81 OR 0.62, 0.20 to 1.97 OR 0.97, 0.22 to 4.22 OR 1.73, 0.68 to 4.43 OR 1.60, 0.40 to 5.86	Age>65, sex, HT or CVD, CLD, DM	

Sparks	Worldwide	GRA COVID-19	24 Mar 20 to 12 Apr 21	Cross-sectional, registry	Secondary care	b/tsDMARD treated patients with RA and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	137/2,869 (hospitalised) 319/2,869 (hospitalised with oxygen or ventilation) 157/2,869 (death)†	Abatacept (18/237, death) **RTX (54/374, death)** IL-6i (9/317, death) **JAKi (40/563, death)**	TNFi TNFi TNFi TNFi	OR 1.26, 0.88 to 1.80 **OR 4.15, 3.16 to 5.44** OR 0.81, 0.56 to 1.18 **OR 2.06, 1.60 to 2.65**	Age, sex, region, calender time, obesity, smoking, concomitant use of csDMARDs, GC use and dosage, comorbidity count, HT/CVD, ILD, cancer, disease activity	Sens+
Trefond	France	French COVID-19 registry	13 Apr to 29 Jul 20	Cross-sectional, registry	Secondary care	Patients with inflammatory RMD and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical CT imaging or highly suspected based on clinical symptoms	26/262 (ICU or death)	HCQ (8/71)	No HCQ	OR 1.94, 0.69 to 5.41	Age, sex, comorbidity, immunosuppressive drug use, SARS-CoV-2 PCR positivity	
Ugarte-Gil (OP0286)	Worldwide	GRA COVID-19	24 Mar 20 to 8 Jan 21	Cross-sectional, registry	Secondary care	Patients with SLE and COVID-19; cases reported by rheumatologists	Physician diagnosis	PCR+ or serology+ or typical imaging or symptoms after contact with case or highly suspected based on clinical symptoms	116/1,069 (hospitalised + non-invasive ventilation) 25/1,079 (hospitalised + IMV/ECMO) 78/1,069 (death)†	**No immunosuppressive drugs (NR)** csDMARD monotherapy (NR) b/tsDMARD monotherapy (NR) cs/b/tsDMARD combination therapy (NR) **GC 0-5 mg/day (NR)** **GC 5-10 mg/day (NR)** **GC ≥10 mg/day (NR)** **Moderate/high DA (NR)**	Antimalarials Antimalarials Antimalarials Antimalarials No GC No GC No GC Remission/low DA	**OR 2.29, 1.34 to 3.91** OR 1.17, 0.77 to 1.77 OR 1.00, 0.37 to 2.71 OR 1.00, 0.55 to 1.82 **OR 1.98, 1.33 to 2.96** **OR 2.88, 1.27 to 6.56** **OR 2.01, 1.26 to 3.21** **OR 2.24, 1.46 to 3.43**	Age, sex, race, region, calender time, DMARD use, GC use and dosage, comorbidity count, CVD, CKD, disease activity	

*n/N: number of patients with outcome / number of patients exposed to risk factor. **Indicates that there were less than 10 cases with the risk factor and the outcome. †Risk estimates of progression to worse COVID-19 outcome on 4-point ordinal scale. 'Sens+' indicates that a sensitivity analysis was performed, and results were consistent. Statistically significant associations are indicated in **bold**. Colours denote overall RoB assessment of each study (green: low risk of bias, orange: unclear risk of bias, red: high risk of bias).

BMI, body mass index; c, continuous; CKD, chronic kidney disease; CLD, chronic lung disease; CT, computerized tomography; (u)CTD, (undifferentiated) connective tissue disease; CVD, cardiovascular disease; DA, disease activity; DM, diabetes mellitus; (ts/b/cs)DMARD, (targeted synthetic/biologic/conventional synthetic) disease-modifying anti-rheumatic drug; FM, fibromyalgia; GC, glucocorticoid; HCQ, hydroxychloroquine; HR, hazard ratio; HT, hypertension; ICU, intensive care unit; IJD, inflammatory joint disease; IL, interleukin; IMV, invasive mechanical ventilation; JAKi, janus kinase inhibitor; MMF, mycophenolate mofetil; MTX, methotrexate; NR, not reported; NSAID, non-steroidal anti-inflammatory drug; OA, osteoarthritis; OP, osteoporosis; OR, odds ratio; PCR, polymerase chain reaction; PsA, psoriatic arthritis; RA, rheumatoid arthritis; RMD, rheumatic and musculoskeletal diseases; RoB, risk of bias; RR, risk ratio; RTX, rituximab; SES, socioeconomic status; SLE, systemic lupus erythematosus; SpA, spondyloarthritis; SSZ, sulfasalazine; TNFi, tumor necrosis factor alpha inhibitor; UK, United Kingdom; USA, United States of America.

Supplementary Table 12: Vaccination against SARS-CoV-2 in patients with RMDs

Supplementary Table 12. Studies with data on vaccination against SARS-CoV-2 in patients with RMDs											
First author	**Country**	**Study type**	**Study population; recruitment**	**Study period; follow-up; time between first and second vaccination**	**Vaccine type**	**N**	**Case definition RMD**	**Demographics RMD pts** N; age mean±SD or median, IQR; % women; race; RMD type	**Assessment of vaccine response** Time of assessment; type of assay	**Vaccine response and associated factors**	**Safety**	**RoB**
Boyarsky*	USA	Cross-sectional	Patients with RMD who received first vaccine dose; via social media	8 Jan to 12 Feb 21; assessment median 3 weeks after second vaccine dose; NR	BNT162b2 (52%), mRNA-1273 (48%)	123	NR (likely self-reported)	123; 50, 41-61 y; 95% F; 90% white; IA 34%, SLE 20%, SjS 13%, myositis 6%, vasculitis 2%, overlap CTD 29%, other 4%	median (IQR) 22 (18-26) days after first vaccine; Roche Elecsys anti-SARS-CoV-2 S ELISA	n/N (%) detectable antibodies: 91/123 (74) Negative association: - Increased age (p=0.06) - Mycophenolate (p=0.001, 3/11) - RTX (p=0.04, 2/6) Positive association: - TNFi (p=0.07, 16/17) Not associated: sex, race, RMD type, other DMARDs (azathioprine, hydroxychloroquine, sulfasalazine, tacrolimus, leflunomide, MTX, abatacept, belimumab, ILi, tofacitinib)	NR	
Braun-Moscovici (pre-print)	Israel	Prospective	Patients with IRMD who received first vaccine dose; at routine outpatient clinic visit	NR; until 4-6 weeks after second vaccine dose; NR	BNT162b2	156	Physician diagnosis	156; 59, r 21-83 y; 76% F; NR; IA 50%, SLE 12%, 29% CTD, 6% vasculitis, 1% other	4-6 weeks after second vaccine; Abbott SARS-CoV-2 IgG II Quant ELISA	n/N (%) detectable antibodies: 137/156 (88) Medication in undetectable antibody response (n=19): RTX (9/19), abatacept (2/2), MMF monotherapy (3/15), belimumab and MMF (1), secukinumab (1), prednisolone 20 mg (1), chemotherapy for lung neoplasm (1), obinutuzumab (1)	Minor AEs (muscle sore, headache, low grade fever); 1 patient with FMF and ILD reported new onset arthritis (2 weeks after first vaccine dose); no flare-up of underlying IRMD within two months after first vaccine in other patients reported	
Connolly*	USA	Cross-sectional	Patients with RMD who received first vaccine dose; via social media	17 Dec 20 to 11 Feb 21; questionnaire one week after first vaccine; NA	BNT162b2 (51%), mRNA-1273 (49%)	325	NR (likely self-reported)	325; 43, 34-54 y; 96% F; 89% white; IA 38%, SLE 28%, overlap CTD 19%	NA	NR	1 (0.3%) post-vaccination PCR+ COVID-19; local symptoms in 89% (pain, swelling, erythema); systemic symptoms in 69% (fatigue (7% severe), headache, myalgia, chills, fever, diarrhoea, vomiting); 10 (3%) infection requiring treatment; 1 (0.3%) peripheral neuropathy; no major allergic reactions	
Cuomo (POS1248)	Italy	Prospective	Patients with RMD who received one or two vaccine doses; NR	Until 30 Jan 21; NR; 21 days	BNT162b2	57	NR	27; 48.7±11 y; 78% F; NR; PsA 37%, RA 22%, SSc 19%, SpA 11%, SLE 7%, SjS 4%	NA	NR	≥1 AE after first vaccine in 59% cases vs 63% controls and after second dose in 83% (5/6) cases vs 91% (10/11) controls; most reported: injection site pain (n=17), headache (n=16), and fatigue (n=5) after first vaccine and headache (n=10), fatigue (n=10), fever (n=10) and injection site pain (n=7) after second vaccine; no serious AE occurred	
Deepak (pre-print)	USA	Prospective	Patients with chronic inflammatory disease (including IRMD; cases) and immunocompetent controls 2 weeks prior to first vaccine dose; faculty, employees, staff and patients from multiple (healthcare) centers	10 Dec 20 to 20 Mar 21; until 20 days after second vaccine dose; NR	mRNA SARS-CoV-2 vaccination (type not specified)	186	NR	133; 45.5±16 y; 74% F; 88% white; IBD 31.6%, RA 28.6%, SpA 15%, uveitis 4%, SLE 11%, other CTD 3%, SjS 6%, vasculitis 4%, autoinflammatory syndrome 2%, multiple sclerosis 7%, other 5%	mean 8.5±2.8 days after second vaccine; anti-S IgG SARS-CoV-2 ELISA and neutralization assay	Cases vs controls: 3-fold lower IgG Ab (p=0.0092) and neutralizing titres (p<0.001) Negative association (fold lower Ab titre, 95% CI) - B-cell depleting therapy (52.7, 18.3-152.0, n=10) - Prednisone (15.1, 4.9-46.3, n=14) - JAKi (6.6, 2.9-15.3, n=10) - Antimetabolites incl. MTX (2.9, 1.5-5.6, n=31) Not associated (fold lower Ab titre, 95% CI) - Antimalarials (2.2, 0.96-5.0, n=14) - TNFi (1.7, 0.92-3.2, n=21) - Cases with various other or no medication (1.6, 0.92-2.8, n=33)	NR	
Furer	Israel	Prospective	Patients with IRMD (cases) and healthy controls (mainly health care personnel) scheduled for vaccination; outpatient clinic (cases), recruitment of healthy controls NR	Dec 20 to Mar 21; assessment 2-6 weeks after vaccine dose; 21 days	BNT162b2	807	Classification criteria	686; 59, r 19-88 y; 69% F; NR; RA 38%, PsA 24%, SpA 10%, SLE 15%, IIM 3%, vasculitis 14%	2-6 weeks after second vaccine; Liaison (DiaSorin) anti-S IgG SARS-CoV-2 assay	IgG Ab, cases vs controls: - Detectable in n/N (%) 590/686 (86) vs 121/121 (100) (p<0.001) - Titre mean±SD 132.9±91.7 vs 218±82.1 (p<0.001) Negative association (OR for seropositivity, 95% CI, adjusted for age, RMD type, MTX and anti-CD20 therapy) - Age >65 y (0.43, 0.25-0.75, n=246) - RA (0.31, 0.11-0.82, n=263, vs PsA) - IIM (0.06, 0.02-0.27, n=19, vs PsA) - AAV (0.04, 0.01-0.17, n=26, vs PsA) - anti-CD20 (0.13, 0.07-0.24, n=87) [higher seropositivity rate in cases with ≥1 year interval between vaccination and RTX infusion (50%) vs ≤ 6 months interval (20%)] - GC (0.48, 0.26-0.87, n=130)	1 (0.1%) post-vaccination COVID-19 in control subject; similar prevalence of mild AE in cases vs controls; no serious AE in control group, 2 deaths post-vaccination in cases; disease activity indices of RA, PsA, SpA and SLE patients remained stable	

										- Abatacept (0.14, 0.04-0.43, n=16) - Mycophenolate (0.1, 0.03-0.34, n=28) Not associated (OR for seropositivity, 95% CI, adjusted for age, RMD type, MTX and anti-CD20 therapy): SpA, SLE, LVV, other vasculitis, MTX (0.58, 0.31-1.07, n=176), TNFi, IL6i, IL17i, JAKi		
Geisen	Germany	Prospective	Patients with chronic inflammatory disease patients (including IRMD; cases) and healthy controls prior to first vaccine dose; healthcare workers and sample of elderly patients from outpatient clinic	NR; until 14 days after second vaccine dose; 35 days (21 days for those aged>80 years)	BNT162b2 (93%), mRNA-1273 (7%)	68	NR	26; 50.5±16 y; 64% F; NR; RA 31%, psoriasis 15%, IBD 12%, SpA 12%, PsA 8%, SLE 8%, sarcoidosis 4%, MCTD 4%, vasculitis 4%, myositis 4%	7 days after second vaccine; Euroimmun Quantivac IgG SARS-CoV-2 ELISA, cPass neutralisation assay and Aeskulisa IgA SARS-CoV-2 ELISA	IgG Ab, cases vs controls: - Detectable in n/N (%) 26/26 (100) vs 42/42 (100) - Titre mean±SD 2053±1218 vs 2685±1102, p=0.037 Neutralizing activity, cases vs controls: - Detectable in n/N (%) 26/26 (100) vs 42/42 (100) - Activity level mean±SD 87±18 vs 96±1.6, p=0.0442 IgA Ab, cases vs controls: - Detectable in n/N (%) 3/26 (12) vs 3/42 (7) - Titre mean±SD 24.5±30.5 vs 47.7±45.1, p=0.0035	Numerical differences in mild systemic side effects in cases vs controls: fatigue (53.8 vs 43.2%), myalgia (42.3 vs 31.6%), headache (38.5 vs 35.1%), fever (0 vs 13.5%); no inflammatory arthritis flare measured using DAS28 post-vaccination and no therapy adjustments needed in cases	
Haberman (*Methotrexate hampers*)	USA and Germany	Cross-sectional	Two independent cohorts of TNFi and MTX treated patients with IRMD (cases) and healthy controls prior to first vaccine dose; patients from SAGA cohort (USA) and outpatient clinic (Germany), recruitment of healthy controls NR	23 Dec 20 to 31 Mar 21; assessment one week after second vaccine dose; mean 32 (USA) and 47 (Germany) days	BNT162b2	290	NR	USA cohort 51; 56.2±13.5 years; 68% F; 70% white; RA 43%, psoriasis or PsA 47%, other 10% German cohort 31; 51.1±18 years; 71% F; 94% white; NR	7 days after second vaccine; direct IgG SARS-CoV-2 ELISA (USA), Euroimmun IgG SARS-CoV-2 ELISA (Germany) and 35-spectral flow cytometry on peripheral blood monocyte cells	USA; IgG Ab, MTX+ vs MTX- vs controls: - Detectable in n/N (%) 18/25 (72) vs 24/26 (92) vs 25/26 (96) (p=0.023) - Titre median (range) 46,901 (25-694,528) vs 113,608 (25-737,310) vs 104,354 (141-601,185) (p=0.294) Germany; IgG Ab, MTX mono vs TNFi mono vs controls: - Detectable in n/N (%) 10/20 (50) vs 10/11 (91) vs 179/182 (98) (p<0.001) - Optical density median (range) 5.9 (0.95-13.5) vs 7.8 (2.3-11.3) vs 9.4 (1.2-14) (p<0.001) All; IgG Ab, MTX+ vs MTX- vs controls: - Detectable in 62% vs 92% vs 98% - Age<55, detectable in 69% vs 100% vs 99% - Age ≥55, detectable in 59% vs 77% vs 95% USA; flow cytometry, 18 MTX+ vs 24 MTX- vs 20 controls: - Spike-specific B cells, T follicular helper cells, activated CD4+ T cells, HLA-DR+ CD8+ T cells significantly increased in all groups - Activated CD8+ T cells and granzyme B producing CD8+ T cells only induced in MTX- and controls	NR	
Machado (LB0002)	Europe	Cross-sectional, registry	Patients with RMD who received at least one vaccine dose; cases reported by clinicians	5 Feb 21 to 27 Apr 21; mean±SD 41±26 days after first and 26±23 days after second vaccine dose (34% received one and 66% two vaccine doses); NR	BNT162b2 (78%), ChAdOx1 (17%), mRNA-1273 (5%), other/unknown (1%)	1519	Physician diagnosis	1519; 63±16 y; 68% F; NR; IA 51%, CTD 19%, vasculitis 16%, other immune-mediated IRMD 4%, non-IRMD 9%	NA	NR	18/1519 (1%) post-vaccination COVID-19 (mean±SD time to diagnosis 24±17 days after vaccine); 73/1375 (5%) disease flare of whom 17/1375 (1.2%) severe flare (mean±SD time to flare 5±5 after vaccine); ≥1 adverse event in 31%, of which majority early minor adverse events (injection site pain 19%, fatigue 11%, headache 7%); systemic AE in 2% of which 2 (0.1%) severe AE	
Ramirez (*Correspondence on Immunogenicity*)	Italy	Cross-sectional	Patients with IRMD (98% healthcare workers) who received two vaccine doses; consecutive patients at outpatient clinic	31 Dec 20 to 26 Mar 21; assessment median 9 weeks and 6 weeks after second vaccine dose; NR	BNT162b2	55	Physician diagnosis	55; 52, 45-59 y; 45% F; NR; CTD 27%, IA 35%, vasculitis 15%, IgG4-related disease 13%, primary immunodeficiencies 5%, adult-onset Still's disease 2%, sarcoidosis 2%, other 2%	NA	NR	0 post-vaccination COVID-19; no severe AE; ≥1 AE in 69% (47% after first, 56% after second dose; onset median within 24h and resolution in 48h); most reported: constitutional symptoms (49%) and local pain at injection site (38%); demographic factors: more AE in younger and female patients; RMD type: IgG4-related disease less frequent AE, IA more frequent constitutional symptoms; RMD medication: bDMARDs more frequent constitutional symptoms	
Ruddy*	USA	Cross-sectional	Patients with RMD who received two vaccine doses; via social media	12 Jul 20 to 16 Mar 21; assessment median 4 weeks after second vaccine dose; median (IQR) 27 (21-28) days	BNT162b2 (49%), mRNA-1273 (51%)	404	NR (likely self-reported)	404; 44, 36-57 y; 96% F; 91% white; IA 45%, SLE 22%, SjS 5%, myositis 6%, SSc 1% vasculitis 2%, overlap CTD 21%	median (IQR) 29 (28-32) days after second vaccine; Roche Elecsys anti-SARS-CoV-2 S ELISA	n/N (%) detectable antibodies: 378/404 (94) Negative association - Mycophenolate (p<0.001, 30/41) - RTX (p<0.001, 5/19) - GC (p<0.001, 96/117) [86% of negative responders had RTX or mycophenolate comedication]	0 post-vaccination COVID-19	

										- Myositis (p=0.01, 19/24) [80% of negative responders had RTX or mycophenolate comedication] Positive association - TNFi (p<0.001, 98/98) - IA (p<0.001, 179/180) - Combination therapy (p<0.001, 184/208) Not associated: Age, sex, race, SLE, SjS, overlap CTD, vaccine type, time between vaccine dose, prior COVID-19 diagnosis, other DMARDs (azathioprine, hydroxychloroquine, leflunomide, MTX, sulfasalazine, abatacept, belimumab, ILi, JAKi, immunoglobulins)		
Simon	Germany	Cross-sectional	Patients with chronic inflammatory disease patients (including IRMD; cases) and healthy controls ≥10 days after first vaccine dose; cases and controls from large longitudinal COVID-19 study at local research center	28 Dec 20 to 20 Mar 21; assessment ≥10 days after first vaccine dose (96% received two vaccine doses); NR	BNT162b2	266	NR	84; 53.1±17.0 y; 66% F; NR; SpA 32%, RA 30%, IBD 10%, psoriasis 10%, systemic disease 19%	NR; Euroimmun Quantivac IgG SARS-CoV-2 ELISA and cPass neutralisation assay	IgG Ab, cases vs controls: - Detectable in n/N (%) 79/84 (94) vs 182/182 (100) (p=0.003) - Age-, sex- and time-adjusted optical density mean (95%CI) 6.90 (6.45-7.35) vs 8.48 (8.12-8.85) Neutralizing activity, cases vs controls: - Detectable in n/N (%) 76/84 (91) vs 181/182 (99) (p=0.008) Not associated (in cases): Different chronic inflammatory diseases (similar optical density), use of b/tsDMARDs compared to csDMARDs or no treatment	Assessed in 70 cases and 164 controls: AE more frequent after second vaccination, generally mild with injection site pain most frequently observed in both groups	
Spiera	USA	Retrospective	Patients with IRMD after first vaccine dose and serological data; outpatient clinic visit between 24 Feb and 8 Apr 21	24 Feb and 8 Apr 21; NR; NR	BNT162b2 (57%), mRNA-1273 (43%)	89	Physician diagnosis	89; 61.3±16.1 y; 76% F; 94% white; RA 26%, SLE 10%, SjS 11%, SSc 6%, PsA 7%, GPA 13%; GCA 2%, PMR 3%, MPA 4%, other 17%	NR; Roche elecsys anti-SARS-CoV-2 (94%) or Siemens healthineers SARS-CoV-2 total assay atellica IM or ADVIA centaur XP/XPT (6%)	n/N (%) detectable antibodies: 68/89 (76) Negative association - RTX (10/30), with longer interval between vaccination and RTX infusion in those with a positive (median, IQR: 704, 540-1035 days) vs negative serological response (98, 64-164) (no statistical analysis performed)	NR	
Yang (POS1255)	USA	Prospective	Patients with chronic inflammatory disease patients (including IRMD) scheduled to receive vaccination; NR	NR; pre-vaccine until after second vaccine dose; NR	BNT162b2 (57%), mRNA-1273 (43%)	70	NR	70; 48.3±16.4 y; 69% F; 67% white; RA 30%, SpA 30%, SLE 11%, other CTD 17%, vasculitis 4%, IBD 10%, autoinflammatory syndrome 7%, multiple sclerosis 3%, IgG4-related disease 3%	NA	NR	≥1 AE within 7 days after vaccination in 96% after first and 100% after second dose; after first dose generally mild adverse events (77%); after second dose more moderate (48%) or severe (31%) adverse events; most frequently reported were injection site pain (>80%), arthralgia (22% dose 1, 78% dose 2), fever (22% dose 1, 70% dose 2) and fatigue (22% dose 1, 65% dose 2).	

*Reports of different outcomes and/or different follow-up moments of the same study. Colours denote overall RoB assessment of each study (green: low risk of bias, orange: unclear risk of bias, red: high risk of bias).

AAV, ANCA-associated vasculitis; Ab, antibody; AE, adverse event; (ts/b)DMARD, (targeted synthetic/biologic) disease-modifying anti-rheumatic drug; BNT162b2, vaccine developed by Pfizer/BioNTech; ChAdOx1 nCoV-19, vaccine developed by AstraZeneca; (u)CTD, (undifferentiated) connective tissue disease; ELISA, enzyme-linked immunosorbent assay; F, female; FMF, familial Mediterranean fever; GC, glucocorticoids; GCA, giant cell arteritis; IA, inflammatory arthritis; IBD, inflammatory bowel disease; IIM, idiopathic inflammatory myopathies; ILD, interstitial lung disease; IQR, interquartile range; MMF, mycophenolate; MPA, microscopic polyangiitis; mRNA-1273, vaccine developed by Moderna; MTX, methotrexate; NA, not applicable; NR, not reported; OR, odds ratio; PCR, polymerase chain reaction; PMR, polymyalgia rheumatica; PsA, psoriatic arthritis, RA, rheumatoid arthritis; (n)(I)RMD, (non-)(inflammatory) rheumatic and musculoskeletal diseases; RoB, risk of bias; RTX, rituximab; SjS, Sjögren syndrome; SLE, systemic lupus erythematosus; SpA, spondyloarthritis; SSc, systemic sclerosis; USA, United States of America; y, years.

Supplementary Table 13: Updated literature search on vaccination against SARS-CoV-2 in patients with RMDs

Table. Studies with data on vaccination against SARS-CoV-2 in patients with RMDs: updated literature search.											
First author	**Country**	**Study type**	**Study population; recruitment**	**Study period; follow-up; time between first and second vaccination**	**Vaccine type**	**N**	**Case definition RMD**	**Demographics RMD pts** N; age mean±SD or median, IQR; % women; race; RMD type	**Assessment of vaccine response** Time of assessment; type of assay	**Vaccine response and associated factors**	**Safety**
Ammitzbøll†	Denmark	Cross-sectional	Patients with RA or SLE who received two vaccine doses; from longitudinal COPANARD cohort followed since pandemic's first wave	Dec 20 to Apr 21; assessment 1 week after second vaccine dose; median 21 (IQR 21-24) days	BNT162b2	134	Classification criteria	RA: 73; 70.3, 66.9-73.5 y; 67% F; 100% white SLE: 61; 60.2, 46.3-67.1 y; 77% F; 98% white	1 week after second vaccination; VITROS IgG SARS-CoV-2 CLIA	IgG Ab: - Detectable in n/N (%) 103/134 (77) Negative association: - RTX (4/17, 24% responders; time since last infusion did not influence Ab levels) - Combination treatment bDMARD and MTX (not statistically significant) Not associated: age, RMD type after adjustment for RTX	NR
Barbhaiya	USA	Cross-sectional	Patients with systemic rheumatic diseases who received at least one vaccine dose; rheumatology outpatient clinic	Until 12 Apr 21; NR; NR	BNT162b2 (54%), mRNA-1273 (44%), Ad26.COV2.S (1.5%), ChAdOx1 (0.3%)	1101	ICD-10	1101 (42% response rate); 60.8±14.2 y; 81% F; 86% white, 5.7% Hispanic/Latin; NR	NR	NR	202 self-reported disease flare ('sudden worsening of rheumatology condition or arthritis within 2 weeks of vaccination') in 165/1101 patients (15%); most flares were moderate to severe (60%), consisted of joint pain or swelling, muscle aches and fatigue, started 1 (28%), 2-7 (61%) or >7 (11%) days post-vaccination, and resolved within 7 (65%), 8-21 (26%) or after >21 (8.9%) days; no differences in frequency or flare/patient characteristics between first and second vaccination
Bartels†	Denmark	Cross-sectional	Patients with RA or SLE who received two vaccine doses; from longitudinal COPANARD cohort followed since pandemic's first wave	Until 1 Jul 21; assessment 1 week after second vaccine dose; median 22 (IQR 21-24) days	BNT162b2	282	Classification criteria	RA: 154; 63.4 (56.0-71.2) y; 71% F; NR SLE: 128; 53.8 (41.4-62.8) y; 88% F; NR	NR	NR	78% local AE, generally mild; 80% systemic AE (mainly fever, fatigue, headache, chills, muscle pain, joint pain or vomiting) of which 5 (1.8%) lead to emergency department visit but no hospitalisations or deaths
Benucci	Italy	Cross-sectional	Patients with RA treated with RTX who received two vaccine doses; NR	NR; assessment 3 weeks after second vaccine dose; 21 days	BNT162b2	14	NR	14; mean 57 y; NR; NR; RA	3 weeks after second vaccination; B-lymphocyte populations by flow cytometry, ThermoFisher IgG SARS-CoV-2 FEIA and SARS-CoV-2-specific T-cell response by SARS-CoV-2-IGRA Euroimmun IFN-γ release ELISA	No or low IgG Ab values in n/N (%) 4/14 (29), of whom all showed a mediated CD8+ T-cell response of >2500 mU/mL in the IFN-γ release assay	NR
Bixio	Italy	Prospective	Patients with RA in clinical remission who received two vaccine doses; NR	NR; 3 months before first and 3 months after second vaccination; NR	BNT162b2	77	NR	77; 62.2±13.2 y; 81% F; NR; RA	NR	NR	All patients discontinued antirheumatic therapies around vaccination; disease flare (concordant assessment between patient and rheumatologist and DAS28-CRP elevation >1.2) in 6/77 (7.8%) patients, generally after second vaccination (5/6) within mean 2.6 days and resolved within 2 weeks (mean 6.4 days), of which 1 severe flare
Boekel	Netherlands	Cross-sectional	Patients with IRMD or MS (cases) and healthy controls after first or second vaccine dose; cases and controls from two ongoing prospective COVID-19 cohort studies	26 Apr 20 to 1 Mar 21; assessment ≥14 days after first or ≥7 days after second vaccine dose; 4-12 weeks dependent on vaccine type	ChAdOx1 nCoV-19 (56%), BNT162b2 (38%), mRNA-1273 (6%), Ad26.COV2.S (0.3%)	921	NR	632; 63±11 y; 67% F; NR; RA 41%, PsA 11%, SpA 12%, JIA 1%, SLE 5%, vasculitis 2%, PMR 6%, SjS 5%, MS 9%, other rheumatic disease 16%	≥14 days after first or ≥7 days after second vaccination; IgG SARS-CoV-2 ELISA	IgG Ab after first dose, cases vs controls: - Detectable in n/N (%) 210/432 (49) vs 154/210 (73) (no previous SARS-CoV-2 infection) and 72/75 (96) vs 28/29 (97) (with previous infection) - Titre median (IQR) 3.9 (1.0-11.0) vs 8.1 (3.8-21.5) (no previous SARS-CoV-2 infection) and 127.0 (27.3-300.0) vs 145 (87.2-275.0) (with previous infection) IgG Ab after second dose, cases vs controls: - Detectable in n/N (%) 97/106 (92) vs 38/40 (95) (no previous SARS-CoV-2 infection) and 17/19 (89%) vs 9/10 (90%) (with previous infection) - Titre median (IQR) 48.6 (16.7-134.0) vs 86.7 (44.6-205.0) (no previous SARS-CoV-2 infection) and 82.3 (31.0-270.0) vs 114.0 (62.2-252.8) (with previous infection) Negative association (after first dose): - MTX (OR 0.15, 95% CI 0.09-0.25) - Anti-CD20 therapy (OR 0.01, 0.002-0.14) Not associated (after first dose): no immunosuppressive therapy, TNFi or GC	NR

										monotherapy, RMD type, vaccine type (ChAdOx1 vs BNT162b2)	
Bonelli	Austria	Cross-sectional	Patients with IRMD treated with RTX who received two vaccine doses (cases) and sex-matched healthy controls with and without vaccination; cases followed at outpatient clinic, controls NR	NR; assessment 12-23 days after second vaccine dose; NR	BNT162b2	13	NR	5; mean 53 y; 60% F; NR; AAV, CTD, EGPA, immune-mediated necrotizing myopathy, SLE	12-23 days after second vaccination; Elecsys IgG SARS-CoV-2 ELISA and T-cell response by QuantiFERON SARS-CoV-2 IFN-γ release ELISA	IgG Ab, cases vs vaccinated controls: - Detectable in n/N (%) 2/5 (40) vs 4/4 (100) SARS-CoV-2 IFN-γ release: Detected in all cases and vaccinated controls, independent of humoral response Positive association: Detectable CD19+ B-cells	NR
Cherian	India	Cross-sectional	Patients with RMD who received first vaccine dose; followed at outpatient clinic or contacted via telemedicine	Until 10 May 21; assessment 7 days after first vaccine dose; NR	ChAdOx1 nCoV-19 (86%), BBV152 (11%), unknown (3.1%)	724	NR	724; 59.9±10.4 y; 80% F; NR; RA 31%, OA 12%, inflammatory OA 11%, pain syndromes 9.7%, FMS 7.9%, SLE 7.2%, SpA 9.4%, vasculitis 4.4%, SSc 2.2%, myositis 2.4%, CTD 3.0%	NR	NR	436/724 (60%) had ≥1 AE (306 with IRMD, 130 with non-inflammatory RMD), generally mild and none led to hospitalisation; all AE lasted <48 hours except 4 patients with increased joint pain post-vaccination requiring NSAIDs (no changes in immunomodulatory therapy were necessary); no differences in AEs between vaccine types
Chiang*	USA	Cross-sectional	Patients with RMD who received complete vaccine regimen; via social media	Dec 20 to May 21; assessment one month after full vaccination; NR	BNT162b2 or mRNA-1273 (96%), Ad26.COV2.S (4%)	1039	NR (likely self-reported)	1039; NR; NR; NR; NR	Median 29 (IQR 28-32) days after full vaccination; Roche Elecsys anti-SARS-CoV-2 S ELISA	IgG Ab, Ad26.COV2.S vs either mRNA vaccine: - Detectable in n/N (%) 36/45 (80%) vs 906/994 (93%) (p=0.03) - Titre median 9.7 vs 250 U/mL (p<0.001) Negative association: (adjusted OR, 95% CI) - Ad26.COV2.S vaccine (3.9, 1.4-10.8) - RTX use (43.4, 21.6-87.3) - GC use (2.7, 1.6-4.6) - Mycophenolate use (8.9, 4.8-16.6)	NR
Connolly* *(Disease flare)*	USA	Prospective	Patients with RMD who received complete vaccine regimen; via social media	16 Dec 20 to 15 Apr 21; 7 days after first to one month after second vaccine dose; NR	BNT162b2 (55%), mRNA-1273 (45%)	1377	NR (likely self-reported)	1377; 47 (37-59) y; 92% F; 10% non-white; IA 47%, SLE 20%; SjS 5%, myositis 5%, vasculitis 3%, SSc 1%, overlap CTD 20%	NR	NR	Assessments 7 days after first and second and one month after second vaccine dose; Flare after first dose in 61 (4%) within median (IQR) 5 (2-12) days; Flare after second dose in 90 (7%) within 11 (3-20) days; Length of flare symptoms median (IQR) 10 (6-22) days; No patients hospitalised post-vaccination; Baseline immunosuppression changed because of flare in 35 (3%); Risk factors for flare requiring treatment (adjusted IRR, 95% CI) were flare in 6 months prior to vaccination (2.36, 1.66-3.36), prior COVID-19 diagnosis (2.09, 1.21-3.6), csDMARD use (0.52, 0.34-0.80), bDMARD use (0.6, 0.39-0.93), combination therapy (1.95, 1.41-2.68)
Connolly* *(Temporary hold)*	USA	Cross-sectional	Patients with RMD treated with mycophenolate who received complete vaccine regimen; via social media	17 Dec 20 to 13 May 21; assessment one month after full vaccination; NR	BNT162b2 or mRNA-1273 (95%), Ad26.COV2.S (5%)	195	NR (likely self-reported)	195; NR; NR; NR; NR	Median 32 (IQR 28-35) days after full vaccination; Roche Elecsys anti-SARS-CoV-2 S ELISA	IgG Ab, withhold vs not withhold mycophenolate: - Detectable in n/N (%) 22/24 (92%) vs 112/171 (65%) (p=0.01) - Titre median 125 vs 7 U/L (p=0.004) Negative association: (adjusted OR, 95% CI) - RTX use (0.07, 0.03-0.42) - GC use (0.13, 0.19-0.74) Positive association: (adjusted OR, 95% CI) - Withholding mycophenolate (7.24, 1.72-44.31)	2/24 (8%) patients who withheld mycophenolate developed a disease flare in the perivaccination period requiring topical and oral glucocorticoids respectively
Cook	USA	Retrospective	Patients with RMD who contracted SARS-CoV-2 infection ≥14 days after complete vaccine regimen; identified using diagnostic billing codes or referred by physicians	30 Jan 20 to 30 Jul 21; NR; NR	BNT162b2 (44%), mRNA-127 (31%), Ad26.COV2.S (25%)	16	NR	16; median 50 y; 75% F; 69% white; RA 38%, IIM 19%, SLE 19%, AS 13%, IgG4RD 6%, MCTD 6%, PsA 6%, hypocomplementemic urticarial vasculitis 6%	NR	NR	15/16 (93%) infections were symptomatic, 6/16 (38%) patients were hospitalised, 4/16 (25%) patients required oxygen therapy, 1/16 required mechanical ventilation, 2/16 (13%) patients died (both had received RTX and suffered from ILD)
Delvino	Italy	Cross-sectional	Patients with GCA who received two vaccine doses; NR	Until 30 Apr 21; assessment 4 weeks after second vaccine dose; NR	BNT162b2	81	NR	81; 75.8±6.9 y; 68% F; NR; GCA 100%	NR	NR	49/81 (60.5%) had ≥1 AE: local injection site reaction (49.4%), fatigue (23.5%), arthralgia (8.6%), myalgia (7.4%), low-grade fever (6.2%), headache (6.2%), chills (3.7%), gastrointestinal symptoms (3.7%), lymphadenopathy (1.2%); mean symptom duration 1.2±1.0 days; arthralgia more common in patients aged >75 vs ≤75 y (16.7% vs 0%, p=0.08)
Esquivel-Valerio	Mexico	Cross-sectional	Patients with RMD who received complete vaccine regimen; followed at outpatient clinic	3 May 21 to 21 Jul 21; NR; NR	BNT162b2 (47.5%), Ad5-nCoV (15.1%), mRNA-127 (12.4%), ChAdOx1 nCoV-19 (12.4%), CoronaVac (9.7%), Ad26.COV2.S (2.2%)	225	NR	225; mean 50.7 y; 95% F; NR; RA 59%, SLE 11%, axSpA 5.3%, SjS 3.5%, IIM 3.5%, other 11%	NR	NR	ChAdOx1 nCoV-19 vs Ad5-nCoV vs Ad26.COV2.S vs mRNA-127 vs BNT162b2 vs CoronaVac: - ≥1 AE (N (%)): 22 (78.5) vs 27 (79.4) vs 5 (100) vs 21 (72.4) vs 86 (80) vs 12 (54.5) - Local AE: 17 (60.7) vs 27 (79.4) vs 5 (100) vs 20 (69) vs 81 (75.7) vs 8 (36.4)

											- Systemic AE: 14 (50) vs 20 (58.8) vs 4 (80) vs 13 (44.8) vs 49 (45.8) vs 7 (31.8) - None of the symptoms was severe enough to require medical attention or hospitalisation
Felten	Worldwide	Cross-sectional	Patients with SLE who received at least one vaccine dose; online survey (recruitment NR)	22 Mar 21 to 17 May 21; assessment after first (51%) or second (49%) vaccine dose; NR	BNT162b2 (57%), CoronaVac (22%), ChAdOx1 nCoV-19 (10%), mRNA-127 (8%), Ad26.COV2.S (0.7%), other (0.9%)	696	Self-reported medically confirmed diagnosis	696; 42 (34-51) y; 96% F; NR; SLE 100%	NR	NR	2683 AEs reported by 316/696 (45%) patients after the first dose and by 181/343 (53%) patients after the second dose; No differences in AEs according to vaccine type; AEs were generally mild to moderate (83%); Increased risk of AE after second vaccine dose in patients suffering from AE after first vaccine dose (RR 2.30, 95% CI 1.88-2.82) 21/696 (3%) patients reported a medically confirmed SLE flare (90% musculoskeletal symptoms, 86% fatigue) median 3 days (IQR 0–29) post-vaccination; 15/21 (71%) of flares required treatment change and 4/21 (19%) hospital admission; Increased risk of flare in patients who had flared 12 months prior to vaccination (RR 5.52, 95% CI 2.17-14.03)
Izmirly	USA	Prospective	Patients with SLE (cases) and healthy controls who planned to receive complete vaccine regimen; cases from established NYU Lupus cohort, healthy controls NR	NR; from pre-vaccination to median (range) 24 (5-69) days after complete vaccine regimen; NR	BNT162b2 (68%), mRNA-1273 (27%), Ad26.COV2.S (5.5%)	110	Classification criteria	90; 45.5±14.2 y; 88% F; 48% white, 18% black, 19% Asian, 16% other; SLE 100%	Median (range) 24 (5-69) days after full vaccination; in-house made IgG SARS-CoV-2 ELISA, SARS-CoV-2 microneutralization assay and T-cell response by ELISpot SARS-CoV-2 IFN-γ release assay (subset of 16 cases and 2 controls)	IgG Ab, cases vs controls: - Ab levels pre-vaccine (median (IQR)): 9.1 (2.8-23.9) vs 34.5 (11.2-74.0) (p=0.001) - Ab levels post-vaccine: 235.2 (75.9-531.4) vs 435.7 (269.0-768.6) (p=0.01) Neutralizing activity, cases vs controls: Lower titres in SLE patients (p=0.008) Negative association: (OR, 95% CI) - Immunosuppressive therapy other than antimalarials (15.14, 2.80-82.03) - Normal anti-dsDNA prior to vaccination (14.50, 2.20-95.66) SARS-CoV-2 IFN-γ release: In patients with poor Ab responses also decreased IFN-γ production	9/79 (11%) (with SLEDAI flare index available) patients had a disease flare, of whom 8/9 (89%) mild/moderate (2 arthritis, 2 thrombocytopenia, 1 pleuritis, 1 renal, 1 oral ulcers, 1 pericarditis) and 1/9 (11%) severe (arthritis requiring treatment with MTX)
Lawson-Tovey	Worldwide	Retrospective	Patients with inflammatory RMD who contracted SARS-CoV-2 infection at least ≥14 days after first vaccine dose; reported in GRA-COVID-19 and COVAX registries	19 Jan to 27 Jul 21; NR; NR	BNT162b2 (79%), ChAdOx1 nCoV-19 (11%), CoronaVac (8%), mRNA-1273 (3%)	38	Physician diagnosis	38; 58 (49-65); 76% F; NR; RA 45%, SpA 24%, SSc 8%, SLE 8%	NR	NR	10 fully vaccinated, 28 partially vaccinated; 28/38 patients (74%) fully recovered from the SARS-CoV-2 infection, 3/38 (8%) recovered with ongoing sequelae, 3/38 (8%) died (>80y old male with SSc on GC 10mg/d and MMF after first vaccine dose, >70y old male with RA on GC 5mg/d after two vaccine doses, and >70y old female with RA/SjS on RTX after two vaccine doses); outcome of 4/38 (11%) missing
Medeiros-Ribeiro	Brazil	Prospective	Patients with inflammatory RMD (cases) and age- and sex-matched healthy controls who received two doses of CoronaVac; followed at rheumatology outpatient clinic	Feb to Apr 21; from second vaccine dose to 7 weeks post-vaccination; 28 days	CoronaVac	1192	Classification criteria	910; 51 (40-60); 77% F; 53% white; chronic inflammatory arthritis 50%, RA 28%, SLE 26%, SpA 12%, PsA 9.8%, vasculitis 7.3%, SjS 4.6%, inflammatory myopathies 4.5%, APS 4.1%, SSc 4.5%	28 day and 6 weeks after second vaccination; DiaSorin LIAISON anti-SARS-CoV-2 S1/S2 IgG Ab ELISA and GenScript SRAS-CoV-2 sVNT Kit neutralization assay	IgG Ab, cases vs controls (6 weeks): - Detectable in 70.4% vs 95.5% (p<0.001) - IgG Ab titres 12.1 vs. 29.7 (p<0.001) Neutralizing assay, cases vs controls: - Positive assay in 56.3% vs 79.3% (p<0.001) - Median activity 58.7% vs 64.5% (p=0.013) Negative association with seroconversion: (OR, 95% CI) - Age ≥60 y (0.51, 0.36-0.74, p<0.001) - Prednisone (0.40, 0.28-0.56, p<0.001) - MTX (0.42, 0.29-0.61, p<0.001) - MMF (0.15, 0.09-0.24, p<0.001) - TNFi (0.41, 0.26-0.64, p<0.001) - Abatacept (0.24, 0.13-0.46, p<0.001) - RTX (0.34, 0.13-0.93, p=0.036) Negative association with neutralizing Ab: (OR, 95% CI) - Age ≥60 y (0.65, 0.46-0.91, p=0.011) - Prednisone (0.48, 0.35-0.65, p<0.001) - MTX (0.67, 0.47-0.95, p=0.024) - MMF (0.33, 0.21-0.53, p<0.001) - RTX (0.28, 0.09-0.87, p=0.028)	Mild AE in 50.5% cases vs 40.1% controls after first dose (p=0.011) and in 49% cases vs 34.8% controls after second dose (not significant), no moderate/severe AEs. Incident PCR-confirmed COVID-19 cases post-vaccination in 4% and 1.6% cases and controls (p=0.19); 4 cases were hospitalized for COVID-19 vs none of the controls; no deaths occurred.
Moyon	France	Prospective	Patients with SLE who planned to receive two vaccine doses; followed at outpatient clinic	Until 15 Jan 21; from first vaccine dose to 15 days after second vaccine dose; 21 to 28 days	BNT162b2	126	Classification criteria	12; mean 46.6 y; 91% F; NR; SLE 100%	7-14, 21-28 and 42 days after first vaccination; Genalyte IgG Maverick SARS-CoV-2 multi-antigen serology panel, pseudoneutralization assay, B-cell phenotyping by FACS	Negative association: - MMF (Ab response day 42: β -78, 95% CI -133 to -22, p=0.007; neutralizing activity: -1.1, -1.9 to -0.34, p=0.005) - MTX (-122, -184 to -61, p<0.001; -1.9, -2.7 to -1.1, p<0.001) - Naïve baseline B-cell count (neutralizing activity: 0.04, 0.01-0.07, p=0.006) and low vs normal/high	Within 42 days following first vaccine dose, mild disease flares observed in 3/126 (2.4%) patients; no statistically significant variation in SLEDAI

									and T-cell response by QuantiFERON SARS-CoV-2 IFN-γ release ELISA	naïve B-cell compartment (neutralizing activity: 229.2, 30-2510 vs 468.3, 30-5421, p<0.05) Positive association: - Baseline B-lymphocyte count (Ab response day 42: β 0.38, 95% CI 0.13-0.62, p=0.003), particularly naïve B-lymphocyte count (2.5, 0.87-4.0, p=0.003) - Baseline IgG level (2.0, 0.34-3.6, p=0.018) No association with Ab response at day 42: age, sex, baseline IFN-α or total lymphocyte count, baseline SLE disease activity, antimalarial or GC or belimumab use during study SARS-CoV-2 IFN-γ release: Response in 17/30 (57%) patients with neutralizing Ab titres vs 1/10 (10%) with non-neutralizing Ab titres (p<0.05)	
Picchianti-Diamanti	Italy	Prospective	RA patients treated with bDMARDs except anti-CD20 (cases) and health care workers (controls) who received second vaccine dose in previous 2 weeks; cases followed at outpatient clinic, controls from local health care worker cohort	NR; until 2 weeks after second vaccine dose; NR	BNT162b2	202	Classification criteria	35; 59, 55-65 y; 77% F; 89% West European, 6% East European, 2.8% African, 2.8% South American; RA 100%	2 weeks after second vaccination; Architect i2000sr Abbott Diagnostics anti-SARS-CoV-2 IgG antibodies and T-cell response by QuantiFERON SARS-CoV-2 IFN-γ release ELISA and FACS analysis to identify T-cell subpopulations	IgG Ab, cases vs controls: - Detectable in n/N (%) 34/35 (97) vs 167/167 (100) Negative association with Ab response: - CTLA-4i and IL-6i with/without csDMARD or GC (p<0.0001) No association with Ab response: TNFi with/without csDMARD (p=0.273), csDMARD with/without GC (p=0.421) SARS-CoV-2 IFN-γ release, cases vs controls: - Present in n/N (%) 24/35 (69) vs 167/167 (100) Negative association with IFN-γ release: - TNFi with/without csDMARD (p=0.002) - IL6i with/without csDMARD or GC (p<0.0001) - CTLA-4i with/without csDMARD or GC (p<0.0001)	No significant increase of disease activity (median (IQR) baseline 2.9 (2.4-3.5) vs 2 weeks post-vaccination 3.1 (2.0-3.5), p=0.759); No severe adverse reactions, and 18/35 cases (46%) with mild transient side effects (mainly pain at injection site, mild fever, arthromyalgia, and fatigue)
Rotondo	Italy	Cross-sectional	Patients with inflammatory RMD (cases) and non-inflammatory RMD (controls) >24 days after vaccination; from 2 rheumatology units contacted via an online survey	NR; >24 days after first or second vaccine dose; NR	BNT162b2 (78%), ChAdOx1 nCoV-19 (22%)	185	NR	185; 60.2±14.2 y; 76% F, NR; arthritis 78%, osteoporosis 41%, osteoarthritis 40%, CTD 18%, fibromyalgia 19%, vasculitis 4%	>4 weeks after last vaccine dose (48% after first, 52% after second vaccination); anti-SARS-CoV-2 antibodies using commercially available assays (no details)	No difference in serum levels of IgG Ab between inflammatory RMD patients who interrupted vs did not interrupt treatment (p=0.394)	42% and 26% self-reported AEs after first and second vaccine dose without differences between BNT162b2 and ChAdOx1 nCoV-19 vaccines or inflammatory vs non-inflammatory RMD patients; most common AEs were injection site pain (17%), headache (12%), fever (12%), myalgia (10%) and fatigue (10%); no serious AEs occurred; risk of AE after first vaccine dose lower in older patients (OR 0.95, p=0.001) and in patients with RMD in remission (OR 0.2, p=0.010); relapse of RMD occurred in 2.2% of patients after first vaccine dose
Rubbert-Roth	Switzerland	Prospective	Patients with RA (cases) and healthy controls who received two vaccine doses; NR	NR; from first vaccine dose to 2 weeks after second vaccine dose; NR	BNT162b2 (83%), mRNA-1273 (17%)	73	NR	53; NR; NR; NR; RA 100%	3 weeks after first and 2 weeks after second vaccination; Roche Elecsys anti-SARS-CoV-2 S1 ELISA	IgG Ab, cases vs controls: - Titre >15 U/mL in n/N (%) 5/51 (10) vs 18/20 (90) after first vaccine dose (p<0.001) - Titre >15 U/mL in 45/51 (88) vs 20/20 (100) after second vaccine dose No association: age, sex, disease duration, low-dose GC 13/16 (81%) on csDMARDs, 17/18 (94%) on anti-cytokines, 4/5 (80%) on abatacept, 8/12 (67%) on JAKi developed Ab titres >15 U/mL after second vaccine dose	NR
Sattui	Worldwide	Cross-sectional	Patients with RMD who received at least one vaccine dose; via online survey	2 to 30 Apr 21; NR; NR	BNT162b2 (53%), ChAdOx1 nCoV-19 (23%), mRNA-1273 (21%), Ad26.COV2.S (1.7%), other (1.2%)	2860	Self-reported	2860; 55.3±14.3 y; 87% F; 86.3% white; RA 43%, inflammatory myositis 17%, SjS 15%, SLE 14%, SpA 9.0%, PsA 7.2%, other CTD 6.9%, vasculitis 5.8%, SSc 4.4%, APS 2.4%, autoinflammatory disease 1.1%, sarcoidosis 0.7%	NR	NR	1371/2860 (48%) ≥1 AE lasting for ≥2 days post-vaccination; most reported were fatigue/somnolence (33%), headache (28%), muscle/joint pain (23%) and fever/chills (20%); 6 (0.2%) episodes of self-reported anaphylaxis; self-reported disease flare for ≥2 days post-vaccination in 13% and requiring medication changes in 4.6%; no differences in AEs across vaccine types

*Reports of different outcomes and/or different follow-up moments of the same study, of which the first reports were included in the original literature search (see Supplementary Table 12: Boyarsky et al., Connolly et al. and Ruddy et al.). †Reports of different outcomes and/or different follow-up moments of the same study.

AAV, ANCA-associated vasculitis; Ab, antibody; Ad5-nCoV, vaccine developed by CanSinoBIO; Ad26.COV2.S, vaccine developed by Janssen; AE, adverse event; APS, antiphospholipid syndrome, BBV152, vaccine developed by Bharat Biotech; (ts/b)DMARD, (targeted synthetic/biologic) disease-modifying anti-rheumatic drug; BNT162b2, vaccine developed by Pfizer/BioNTech; ChAdOx1 nCoV-19, vaccine developed by AstraZeneca; CLIA, chemiluminescent immunoassay; CoronaVac, vaccine developed by Sinovac; (u)CTD, (undifferentiated) connective tissue disease; CTLA-4i, cytotoxic T-lymphocyte associated protein 4 inhibitor; EGPA, eosinophilic granulomatosis with polyangiitis; ELISA, enzyme-linked immunosorbent assay; F, female; FACS, fluorescence-activated cell sorting; FEIA, fluorescent enzyme immunoassay; FMF, familial Mediterranean fever; GC, glucocorticoids; GCA, giant cell arteritis; IA, inflammatory arthritis; IBD, inflammatory bowel disease; IFN-γ, interferon γ; IIM, idiopathic inflammatory myopathies; ILD, interstitial lung disease; IQR, interquartile range; IRR, incident rate ratio; MPA, microscopic polyangiitis; mRNA-1273, vaccine developed by Moderna; MS, multiple sclerosis; MTX, methotrexate; NA, not applicable; NR, not reported; NSAID, non-steroidal anti-inflammatory drug; OR, odds ratio; PCR, polymerase chain reaction; PMR, polymyalgia rheumatica; PsA, psoriatic arthritis, RA, rheumatoid

arthritis; (n)(I)RMD, (non-)(inflammatory) rheumatic and musculoskeletal diseases; RTX, rituximab; SjS, Sjögren syndrome; SLE, systemic lupus erythematosus; SLEDAI, SLE disease activity index; (ax)SpA, (axial) spondyloarthritis; SSc, systemic sclerosis; USA, United States of America; y, years

Reference list to included studies

Studies with incidence data

Aries P, Iking-Konert C. No increased rate of SARS-CoV-2 infection for patients with inflammatory rheumatic diseases compared with the general population in the city of Hamburg (Germany). *Ann Rheum Dis* 2020 Published Online First: 07 Aug 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218400

Bachiller-Corral J, Boteanu A, Garcia-Villanueva MJ, et al. Risk of Severe COVID-19 Infection in Patients With Inflammatory Rheumatic Diseases. *J Rheumatol* 2021;15:15.

Benucci M, Damiani A, Giannasi G, et al. Serological tests confirm the low incidence of COVID-19 in chronic rheumatic inflammatory diseases treated with biological DMARD. *Ann Rheum Dis* 2020 Published Online First: 06 Jul 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218214

Bjornsson AH, Grondal G, Kristjansson M, et al. Prevalence, admission rates and hypoxia due to COVID-19 in patients with rheumatic disorders treated with targeted synthetic or biologic disease modifying antirheumatic drugs or methotrexate: a nationwide study from Iceland. *Ann Rheum Dis* 2021;80:671-2.

Blanch-Rubio J, Soldevila-Domenech N, Tio L, et al. Influence of anti-osteoporosis treatments on the incidence of COVID-19 in patients with non-inflammatory rheumatic conditions. *Aging (Albany NY)* 2020;12:19923-37.

Bower H, Frisell T, Di Giuseppe D, et al. Impact of the COVID-19 pandemic on morbidity and mortality in patients with inflammatory joint diseases and in the general population: a nationwide Swedish cohort study. *Ann Rheum Dis* 2021;80:1086-93.

Bozzalla Cassione E, Zanframundo G, Biglia A, et al. COVID-19 infection in a northern-Italian cohort of systemic lupus erythematosus assessed by telemedicine. *Ann Rheum Dis* 2020;79:1382-83.

Chen M, Wei Y, Zhang Q, et al. Epidemiology and clinical characteristics of COVID-19 in rheumatic diseases at a tertiary care hospital in Wuhan, China. *Clin Exp Rheumatol* 2021;39:442-3.

Cleaton N, Raizada S, Barkham N, et al. COVID-19 prevalence and the impact on quality of life from stringent social distancing in a single large UK rheumatology centre. *Ann Rheum Dis* 2021;80:e93.

Comarmond C, Leclercq M, Leroux G, et al. 2019 Novel Coronavirus Disease (COVID-19) in Patients with Large-Vessels Vasculitis: Single-centre Experience in Paris. *Arthritis & Rheumatology* 2020;72:Supl 10.

Cordtz R, Lindhardsen J, Soussi BG, et al. Incidence and severeness of COVID-19 hospitalisation in patients with inflammatory rheumatic disease: a nationwide cohort study from Denmark. *Rheumatology (Oxford)* 2020 Published Online First: 28 Dec 2020. doi: https://dx.doi.org/10.1093/rheumatology/keaa897Espinosa G, Prieto-Gonzalez S, Llevadot M, et al. The impact of SARS-CoV-2 coronavirus infection in patients with systemic lupus erythematosus from a single center in Catalonia. *Clin Rheumatol* 2021;40:2057-63.

Eviatar T, Elalouf O, Furer V, et al. Prevalence of COVID-19 and seroprevalence to SARS-CoV-2 in a rheumatologic patient population from a tertiary referral clinic in Israel. *Intern Med J* 2021;51:682-90.

FAI consortium. Severity of COVID-19 and survival in patients with rheumatic and inflammatory diseases: data from the French RMD COVID-19 cohort of 694 patients. *Ann Rheum Dis* 2020;80:527-38.Favalli EG, Agape E, Caporali R. Incidence and Clinical Course of COVID-19 in Patients with Connective Tissue Diseases: A Descriptive Observational Analysis. *J Rheumatol* 2020;47:1296.

Favalli EG, Monti S, Ingegnoli F, et al. Incidence of COVID-19 in Patients With Rheumatic Diseases Treated With Targeted Immunosuppressive Drugs: What Can We Learn From Observational Data? *Arthritis rheumatol* 2020;72:1600-06.

Fernandez-Gutierrez B, Leon L, Madrid A, et al. Hospital admissions in inflammatory rheumatic diseases during the peak of COVID-19 pandemic: incidence and role of disease-modifying agents. *Ther* 2021;13:1759720X20962692.

Ferri C, Giuggioli D, Raimondo V, et al. POS1246 COVID-19 IN ITALIAN PATIENTS WITH RHEUMATIC AUTOIMMUNE SYSTEMIC DISEASES: RESULTS OF A NATIONWIDE SURVEY STUDY. *Ann Rheum Dis* 2021;80:906-07.

Ferri C, Giuggioli D, Raimondo V, et al. COVID-19 and systemic sclerosis: clinicopathological implications from Italian nationwide survey study. *Lancet Rheumatol* 2021;3:e166-e68.

Ferri C, Giuggioli D, Raimondo V, et al. COVID-19 and rheumatic autoimmune systemic diseases: report of a large Italian patients series. *Clin Rheumatol* 2020;39:3195-204.

Fike A, Hartman J, Redmond C, et al. Risk factors for COVID-19 and rheumatic disease flare in a US cohort of Latino patients. *Arthritis rheumatol* 2021;73:1129-34.

Flood RM, Conway R, Kirby C, et al. Correspondence to: 'Characteristics associated with hospitalisation for COVID-19 in people with rheumatic disease: data from the COVID-19 Global Rheumatology Alliance physician-reported registry' by Gianfrancesco et al. *Ann Rheum Dis* 2020 Published Online First: 19 August 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218733

Jovani V, Calabuig I, Peral-Garrido ML, et al. Incidence of severe COVID-19 in a Spanish cohort of 1037 patients with rheumatic diseases treated with biologics and JAK-inhibitors. *Ann Rheum Dis* 2020 Published Online First: 25 Jun 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218152
Melong Pianta C, Lauper K, Courvoisier D, et al. Incidence of COVID-19 in patients treated with infliximab com-pared to patients treated with rituximab. *Arthritis rheumatol* 2020;72:Suppl 10.
Mena-Vázquez N, Manrique-Arija S, Cabezudo-Garcia P, et al. Incidence and case fatality rate of COVID-19 in patients with inflammatory articular diseases. *Int J Clin Pract* 2020;75:e13707.
Michelena X, Borrell H, Lopez-Corbeto M, et al. Incidence of COVID-19 in a cohort of adult and paediatric patients with rheumatic diseases treated with targeted biologic and synthetic disease-modifying anti-rheumatic drugs. *Semin Arthritis Rheum* 2020;50:564-70.
Murray K, Quinn S, Turk M, et al. COVID-19 and rheumatic musculoskeletal disease patients: infection rates, attitudes and medication adherence in an Irish population. *Rheumatology (Oxford)* 2020;60:902-06.
Pablos JL, Abasolo L, Alvaro-Gracia JM, et al. Prevalence of hospital PCR-confirmed COVID-19 cases in patients with chronic inflammatory and autoimmune rheumatic diseases. *Ann Rheum Dis* 2020;79:1170-73.
Quartuccio L, Treppo E, Binutti M, et al. Timing of Rituximab and immunoglobulin level influence the risk of death for COVID-19 in ANCA-associated vasculitis. *Rheumatology (Oxford)* 2021;60:3476–77.
Quartuccio L, Valent F, Pasut E, et al. Prevalence of COVID-19 among patients with chronic inflammatory rheumatic diseases treated with biologic agents or small molecules: A population-based study in the first two months of COVID-19 outbreak in Italy. *Joint Bone Spine* 2020;87:439-43.
Ramirez GA, Gerosa M, Beretta L, et al. COVID-19 in systemic lupus erythematosus: Data from a survey on 417 patients. *Semin Arthritis Rheum* 2020;50:1150-57.
Salvarani C, Bajocchi G, Mancuso P, et al. Susceptibility and severity of COVID-19 in patients treated with bDMARDS and tsDMARDs: a population-based study. *Ann Rheum Dis* 2020;79:986-88.
Salvarani C, Mancuso P, Gradellini F, et al. Susceptibility to COVID-19 in Patients Treated With Antimalarials: A Population-Based Study in Emilia-Romagna, Northern Italy. *Arthritis rheumatol* 2021;73:48-52.
Santos CS, Fernandez XC, Moriano Morales C, et al. Biological agents for rheumatic diseases in the outbreak of COVID-19: friend or foe? *RMD Open* 2021;7:e001439.
So H, Mak JW, So J, et al. Incidence and clinical course of COVID-19 in patients with rheumatologic diseases: A population-based study. *Semin Arthritis Rheum* 2020;50:885-89.
Zen M, Fuzzi E, Astorri D, et al. SARS-CoV-2 infection in patients with autoimmune rheumatic diseases in northeast Italy: A cross-sectional study on 916 patients. *J Autoimmun* 2020;112:102502.

Studies with risk factor data

Alegiani SS, Crisafulli S, Rossi PG, et al. Risk of COVID-19 hospitalization and mortality in rheumatic patients treated with hydroxychloroquine or other conventional DMARDs in Italy. *Rheumatology (Oxford)* 2021 Published Online First: 15 Apr 2021. doi: https://dx.doi.org/10.1093/rheumatology/keab348
Alpizar-Rodriguez D, Irazoque-Palazuelos F, Rodriguez-Reyne TS, et al. POS1242 FACTORS ASSOCIATED WITH MORTALITY IN PATIENTS WITH RHEUMATIC DISEASES AND COVID-19 IN MEXICO. *Ann Rheum Dis* 2021;80:904.
Avouac J, Drumez E, Hachulla E, et al. COVID-19 outcomes in patients with inflammatory rheumatic and musculoskeletal diseases treated with rituximab: a cohort study. *Lancet Rheumatol* 2021;3:e419-26.
Blanch-Rubio J, Soldevila-Domenech N, Tio L, et al. Influence of anti-osteoporosis treatments on the incidence of COVID-19 in patients with non-inflammatory rheumatic conditions. *Aging (Albany NY)* 2020;12:19923-37.
Boteanu A, García Fernández A, De la Torre N, et al. POS1260 FACTORS ASSOCIATED WITH SEVERE SARS-COV-2 INFECTION IN PATIENTS WITH INFLAMMATORY RHEUMATIC DISEASES IN MADRID: RESULTS FROM REUMA-COVID SORCOM REGISTRY. *Ann Rheum Dis* 2021;80:914.
Bower H, Frisell T, Di Giuseppe D, et al. Impact of the COVID-19 pandemic on morbidity and mortality in patients with inflammatory joint diseases and in the general population: a nationwide Swedish cohort study. *Ann Rheum Dis* 2021;80:1086-93.
Chandan JS, Zemedikun DT, Thayakaran R, et al. Non-steroidal anti-inflammatory drugs and susceptibility to COVID-19. *Arthritis rheumatol* 2021;73:731-39.
Cordtz R, Lindhardsen J, Soussi BG, et al. Incidence and severeness of COVID-19 hospitalisation in patients with inflammatory rheumatic disease: a nationwide cohort study from Denmark. *Rheumatology (Oxford)* 2020 Published Online First: 28 Dec 2020. doi: https://dx.doi.org/10.1093/rheumatology/keaa897

D'Silva KM, Jorge A, Cohen A, et al. COVID-19 Outcomes in Patients with Systemic Autoimmune Rheumatic Diseases (SARDs) Compared to the General Population: A US Multi-Center Comparative Cohort Study. *Arthritis rheumatol* 2021;73:914-20.
England BR, Roul P, Yang Y, et al. Risk of COVID-19 in Rheumatoid Arthritis: A National Veterans Affairs Matched Cohort Study in At-Risk Individuals. *Arthritis rheumatol* 2021 Published Online First: 05 May 2021. doi: https://dx.doi.org/10.1002/art.41800
Esatoglu SN, Tascilar K, Babaoglu H, et al. COVID-19 Among Patients With Inflammatory Rheumatic Diseases. *Front Immunol* 2021;12:651715.
FAI consortium. Severity of COVID-19 and survival in patients with rheumatic and inflammatory diseases: data from the French RMD COVID-19 cohort of 694 patients. *Ann Rheum Dis* 2020;80:527-38.
Fernandez-Gutierrez B, Leon L, Madrid A, et al. Hospital admissions in inflammatory rheumatic diseases during the peak of COVID-19 pandemic: incidence and role of disease-modifying agents. *Ther* 2021;13:1759720X20962692.
Francesconi P, Cantini F, Profili F, et al. COVID-19 epidemiology in rheumatic diseases in Tuscany: a case control study. *Joint Bone Spine* 2021;88:105131.
Freites D, Perez-Sancristobal I, Lopez Pedraza L, et al. POS1253 MORTALITY RATE RELATED TO COVID - 19 IN RHEUMATIC AND MUSCULOSKELETAL DISEASES (RMDs). *Ann Rheum Dis* 2021;80:910.
Freites Nuñez DD, Leon L, Mucientes A, et al. Risk factors for hospital admissions related to COVID-19 in patients with autoimmune inflammatory rheumatic diseases. *Ann Rheum Dis* 2020;79:1393-99.
Gianfrancesco M, Hyrich KL, Al-Adely S, et al. Characteristics associated with hospitalisation for COVID-19 in people with rheumatic disease: data from the COVID-19 Global Rheumatology Alliance physician-reported registry. *Ann Rheum Dis* 2020;79:859-66.
Gianfrancesco MA, Leykina LA, Izadi Z, et al. Association of Race and Ethnicity With COVID-19 Outcomes in Rheumatic Disease: Data From the COVID-19 Global Rheumatology Alliance Physician Registry. *Arthritis rheumatol* 2021;73:374-80.
Haberman RH, Castillo R, Chen A, et al. COVID-19 in Patients With Inflammatory Arthritis: A Prospective Study on the Effects of Comorbidities and Disease-Modifying Antirheumatic Drugs on Clinical Outcomes. *Arthritis rheumatol* 2020;72:1981-89.
Hsu T, D'Silva K, Serling-Boyd N, et al. POS1174 HYPERINFLAMMATION AND CLINICAL OUTCOMES FOR PATIENTS WITH SYSTEMIC RHEUMATIC DISEASES HOSPITALIZED FOR COVID-19: A COMPARATIVE COHORT STUDY. *Ann Rheum Dis* 2021;80:867-68.
Ji W, Huh K, Kang M, et al. Effect of Underlying Comorbidities on the Infection and Severity of COVID-19 in Korea: a Nationwide Case-Control Study. *J Korean Med Sci* 2020;35:e237.
Jorge A, D'Silva KM, Cohen A, et al. Temporal trends in severe COVID-19 outcomes in patients with rheumatic disease: a cohort study. *Lancet Rheumatol* 2021;3:E131-37.
Juge PA, Hachulla E, Richez C, et al. POS1227 IMPACT OF A PRE-EXISTING INTERSTITIAL LUNG DISEASE ON SEVERITY OF COVID-19 IN PATIENTS WITH RHEUMATIC AND MUSCULOSKELETAL DISEASES. *Ann Rheum Dis* 2021;80:897.
Jung SY, Kim MS, Kim MC, et al. Effect of hydroxychloroquine pre-exposure on infection with SARS-CoV-2 in rheumatic disease patients: a population-based cohort study. *Clin Microbiol Infect* 2021;27:611-17.
Kim JW, Kwak SG, Lee H, et al. Baseline use of hydroxychloroquine or immunosuppressive drugs and the risk of coronavirus disease 2019. *Korean J Intern Med* 2021 Published Online First: 12 Mar 2021. doi: https://dx.doi.org/10.3904/kjim.2020.633
Madrid-Garcia A, Perez I, Colomer JI, et al. Influence of colchicine prescription in COVID-19-related hospital admissions: a survival analysis. *Ther Adv Musculoskelet Dis* 2021;13:1759720X211002684.
Mena-Vázquez N, Manrique Arija S, Rojas-Gimenez M, et al. Hospitalization and Mortality from COVID-19 of Patients with Rheumatic Inflammatory Diseases in Andalusia. *Reumatol Clin (Engl Ed)* 2021 Published Online First: 20 Mar 2021. doi: https://dx.doi.org/10.1016/j.reuma.2021.02.009
Moiseev S, Avdeev S, Brovko M, et al. Rheumatic diseases in intensive care unit patients with COVID-19. *Ann Rheum Dis* 2021;80:e16.
Pablos JL, Galindo M, Carmona L, et al. Clinical outcomes of hospitalised patients with COVID-19 and chronic inflammatory and autoimmune rheumatic diseases: a multicentric matched cohort study. *Ann Rheum Dis* 2020;79:1544-49.
Pakhchanian H, Raiker R, Qureshi A, et al. 338 Clinical outcomes in COVID-19 patients with dermatopolymyositis. *J Invest Dermatol* 2021;141:S59.
Perez-Sancristobal I, Lopez Pedraza L, Álvarez Hernandez MP, et al. POS1251 ROLE OF SYSTEMIC AUTOINMUNE CONDITIONS IN HOSPITAL ADMISSIONS RELATED TO COVID-19. *Ann Rheum Dis* 2021;80:908-09.

Profili F, Ballo P, Balzi D, et al. [Chronic diseases and risk of symptomatic COVID-19: results of a case-population study on a sample of patients in the Local Health Unit 'Toscana Centro' (Tuscany Region, Central Italy)]. *Epidemiol Prev* 2020;44:308-14.
Rentsch CT, DeVito NJ, MacKenna B, et al. Effect of pre-exposure use of hydroxychloroquine on COVID-19 mortality: a population-based cohort study in patients with rheumatoid arthritis or systemic lupus erythematosus using the OpenSAFELY platform. *Lancet Rheumatol* 2021;3:e19-e27.
Sbidian E, Penso L, Herlemont P, et al. Comment on 'Baseline use of hydroxychloroquine in systemic lupus erythematosus does not preclude SARS-CoV-2 infection and severe COVID-19' by Konig et al. Long-term exposure to hydroxychloroquine or chloroquine and the risk of hospitalisation with COVID-19: a nationwide, observational cohort study in 54 873 exposed individuals and 155 689 matched unexposed individuals in France. *Ann Rheum Dis* 2020 Published Online First: 28 Aug 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218647
Schafer M, Strangfeld A, Hyrich KL, et al. Response to: 'Correspondence on 'Factors associated with COVID-19-related death in people with rheumatic diseases: results from the COVID-19 Global Rheumatology Alliance physician reported registry'' by Mulhearn et al. *Ann Rheum Dis* 2021 Published Online First: 01 Mar 2021. doi: https://dx.doi.org/10.1136/annrheumdis-2021-220134
Scirè CA, Carrara G, Zanetti A, et al. COVID-19 in rheumatic diseases in Italy: first results from the Italian registry of the Italian Society for Rheumatology (CONTROL-19). *Clin Exp Rheumatol* 2020;38:748-53.
Serling-Boyd N, D'Silva KM, Hsu TY, et al. Coronavirus disease 2019 outcomes among patients with rheumatic diseases 6 months into the pandemic. *Ann Rheum Dis* 2021;80:660-66.
Sparks JA, Wallace ZS, Seet AM, et al. Associations of baseline use of biologic or targeted synthetic DMARDs with COVID-19 severity in rheumatoid arthritis: Results from the COVID-19 Global Rheumatology Alliance physician registry. *Ann Rheum Dis* 2021;80:1137-46.
Strangfeld A, Schafer M, Gianfrancesco MA, et al. Factors associated with COVID-19-related death in people with rheumatic diseases: results from the COVID-19 Global Rheumatology Alliance physician-reported registry. *Ann Rheum Dis* 2021;80:930-42.
Topless RK, Phipps-Green A, Leask M, et al. Gout, Rheumatoid Arthritis, and the Risk of Death Related to Coronavirus Disease 2019: An Analysis of the UK Biobank. *ACR Open Rheumatol* 2021;3:333-40.
Trefond LDEAMC-CNSRDMDEDYMSELAMIQVRMSJB. Impact of hydroxychloroquine used as DMARD on SARS CoV-2 tests and infection evolution in a population of 871 patients with inflammatory rheumatic and musculoskeletal diseases. *Joint Bone Spine* 2021:105226.
Ugarte-Gil MF, Alarcon GS, Seet A, et al. OP0286 CHARACTERISTICS ASSOCIATED WITH SEVERE COVID-19 OUTCOMES IN SYSTEMIC LUPUS ERYTHEMATOSUS (SLE): RESULTS FROM THE COVID-19 GLOBAL RHEUMATOLOGY ALLIANCE (COVID-19 GRA). *Ann Rheum Dis* 2021;80:173-75.
Vila-Córcoles A, Ochoa-Gondar O, Torrente-Fraga C, et al. [Evaluation of incidence and risk profile for suffering Covid-19 infection by underlying conditions among middle-aged and older adults in Tarragona.]. *Rev Esp Salud Publica* 2020;94:26.
Wong AY, MacKenna B, Morton CE, et al. Use of non-steroidal anti-inflammatory drugs and risk of death from COVID-19: an OpenSAFELY cohort analysis based on two cohorts. *Ann Rheum Dis* 2021;80:943-51.
Zhong J, Shen G, Yang H, et al. COVID-19 in patients with rheumatic disease in Hubei province, China: a multicentre retrospective observational study. *Lancet Rheumatol* 2020;2:e557-64.

Studies with vaccination data

Boyarsky BJ, Ruddy JA, Connolly CM, et al. Antibody response to a single dose of SARS-CoV-2 mRNA vaccine in patients with rheumatic and musculoskeletal diseases. *Ann Rheum Dis* 2021;80:1098-99.
Braun-Moscovici Y, Kaplan M, Markovits D, et al. Humoral response to Pfizer mRNA vaccine against SARS CoV2, in patients with autoimmune inflammatory rheumatic diseases and the impact on the rheumatic disease activity. *MedRxiv (pre-print)* 2021 doi: https://doi.org/10.1101/2021.04.02.21254493
Connolly CM, Ruddy JA, Boyarsky BJ, et al. Safety of the first dose of mRNA SARS-CoV-2 vaccines in patients with rheumatic and musculoskeletal diseases. *Ann Rheum Dis* 2021;80:1100-01.
Cuomo G, Atteno M, Naclerio C, et al. POS1248 SAFETY PROFILE OF PFIZER-BIONTECH COVID-19 VACCINE IN PATIENTS WITH RHEUMATIC DISEASES: PRELIMINARY ASSESSMENT. *Ann Rheum Dis* 2021;80:907-08.
Deepak P, Kim W, Paley MA, et al. Glucocorticoids and B Cell Depleting Agents Substantially Impair Immunogenicity of mRNA Vaccines to SARS-CoV-2. *MedRxiv (pre-print)* 2021 doi: https://doi.org/10.1101/2021.04.05.21254656
Furer V, Eviatar T, Zisman D, et al. Immunogenicity and safety of the BNT162b2 mRNA COVID-19 vaccine in adult patients with autoimmune inflammatory rheumatic diseases and in the general population: a

multicentre study. *Ann Rheum Dis* 2021 Published Online First: 14 Jun 2021. doi: 10.1136/annrheumdis-2021-220647
Geisen UM, Berner DK, Tran F, et al. Immunogenicity and safety of anti-SARS-CoV-2 mRNA vaccines in patients with chronic inflammatory conditions and immunosuppressive therapy in a monocentric cohort. *Annals of the Rheumatic Diseases* 2021 Published Online First: 24 Mar 2021. doi: http://dx.doi.org/10.1136/annrheumdis-2021-220272
Haberman RH, Herati R, Simon D, et al. Methotrexate hampers immunogenicity to BNT162b2 mRNA COVID-19 vaccine in immune-mediated inflammatory disease. *Ann Rheum Dis* 2021 Published Online First: 25 May 2021. doi: 10.1136/annrheumdis-2021-220597
Machado PM, Lawson-Tovey S, Hyrich K, et al. LB0002 COVID-19 VACCINE SAFETY IN PATIENTS WITH RHEUMATIC AND MUSCULOSKELETAL DISEASE. *Ann Rheum Dis* 2021;80:199-200.
Ramirez GA, Della-Torre E, Moroni L, et al. Correspondence on 'Immunogenicity and safety of anti-SARS-CoV-2 mRNA vaccines in patients with chronic inflammatory conditions and immunosuppressive therapy in a monocentric cohort'. *Ann Rheum Dis* 2021 Published Online First: 24 May 2021. doi: 10.1136/annrheumdis-2021-220539
Ruddy JA, Connolly CM, Boyarsky BJ, et al. High antibody response to two-dose SARS-CoV-2 messenger RNA vaccination in patients with rheumatic and musculoskeletal diseases. *Ann Rheum Dis* 2021 Published Online First: 24 May 2021. doi: https://dx.doi.org/10.1136/annrheumdis-2021-220656
Simon D, Tascilar K, Fagni F, et al. SARS-CoV-2 vaccination responses in untreated, conventionally treated and anticytokine-treated patients with immune-mediated inflammatory diseases. *Ann Rheum Dis* 2021 Published Online First: 06 May 2021. doi: 10.1136/annrheumdis-2021-220461
Spiera R, Jinich S, Jannat-Khah D. Rituximab, but not other antirheumatic therapies, is associated with impaired serological response to SARS- CoV-2 vaccination in patients with rheumatic diseases. *Ann Rheum Dis* 2021 Published Online First: 11 May 2021. doi: https://dx.doi.org/10.1136/annrheumdis-2021-220604
Yang M, Katz P, Paez D, et al. POS1255 REACTOGENICITY OF SARS-COV-2 VACCINES IN PATIENTS WITH AUTOIMMUNE AND INFLAMMATORY DISEASE. *Ann Rheum Dis* 2021;80:911.

<u>Updated literature search on vaccination against SARS-CoV-2 in patients with RMDs</u>

Ammitzbøll C, Bartels L, Bøgh Andersen J, et al. Impaired Antibody Response to the BNT162b2 Messenger RNA Coronavirus Disease 2019 Vaccine in Patients With Systemic Lupus Erythematosus and Rheumatoid Arthritis. ACR Open Rheumatol 2021;3:622-28.
Barbhaiya M, Levine J, Bykerk V, et al. Systemic rheumatic disease flares after SARS-CoV-2 vaccination among rheumatology outpatients in New York City. Ann Rheum Dis 2021;80:1352-54.
Bartels L, Ammitzbøll C, Andersen J, et al. Local and systemic reactogenicity of COVID-19 vaccine BNT162b2 in patients with systemic lupus erythematosus and rheumatoid arthritis. Rheumatol Int 2021;41:1925-31.
Benucci M, Damiani A, Infantino M, et al. Presence of specific T cell response after SARS-CoV-2 vaccination in rheumatoid arthritis patients receiving rituximab. Immunol Res 2021;69:309-11.
Bixio R, Bertelle D, Masia M, et al. Incidence of Disease Flare After BNT162b2 Coronavirus Disease 2019 Vaccination in Patients With Rheumatoid Arthritis in Remission. ACR Open Rheumatol 2021 Published Online First: 2 Sep 2021. doi: 10.1002/acr2.11336
Boekel L, Steenhuis M, Hooijberg F, et al. Antibody development after COVID-19 vaccination in patients with autoimmune diseases in the Netherlands: a substudy of data from two prospective cohort studies. Lancet Rheumatology 2021 Published Online First: 6 Aug 2021. doi: 10.1016/S2665-9913(21)00222-8
Bonelli M, Mrak D, Perkmann T, et al. SARS-CoV-2 vaccination in rituximab-treated patients: evidence for impaired humoral but inducible cellular immune response. Ann Rheum Dis 2021;80:1355-56.
Cherian S, Paul A, Ahmed S, et al. Safety of the ChAdOx1 nCoV-19 and the BBV152 vaccines in 724 patients with rheumatic diseases: a post-vaccination cross-sectional survey. Rheumatol Int 2021;41:1441-45.
Chiang T, Connolly C, Ruddy J, et al. Antibody response to the Janssen/Johnson & Johnson SARS-CoV-2 vaccine in patients with rheumatic and musculoskeletal diseases. Ann Rheum Dis 2021;80:1365-66.
Connolly C, Chiang T, Boyarsky B, et al. Temporary hold of mycophenolate augments humoral response to SARS-CoV-2 vaccination in patients with rheumatic and musculoskeletal diseases: a case series. Ann Rheum Dis 2021 Published Online First: 23 Sep 2021. doi: 10.1136/annrheumdis-2021-221252
Connolly C, Ruddy J, Boyarsky B, et al. Disease Flare and Reactogenicity in Patients with Rheumatic and Musculoskeletal Diseases Following Two-Dose SARS-CoV-2 Messenger RNA Vaccination. Arthritis rheumatol 2021 Published Online First: 4 Aug 2021. doi: 10.1002/art.41924

Cook C, Patel N, D'Silva K, et al. Clinical characteristics and outcomes of COVID-19 breakthrough infections among vaccinated patients with systemic autoimmune rheumatic diseases. Ann Rheum Dis 2021 Published Online First: 6 Sep 2021. doi: 10.1136/annrheumdis-2021-221326
Delvino P, Bozzalla Cassione E, Biglia A, et al. Safety of BNT162b2 mRNA COVID-19 vaccine in a cohort of elderly, immunocompromised patients with systemic vasculitis. Clin Exp Rheumatol 2021 Published Online First: 16 Sep 2021.
Esquivel-Valerio J, Skinner-Taylor C, Moreno-Arquieta I, et al. Adverse events of six COVID-19 vaccines in patients with autoimmune rheumatic diseases: a cross-sectional study. Rheumatol Int 2021 Published Online First: 7 Oct 2021. doi: 10.1007/s00296-021-05017-9
Felten R, Kawka L, Dubois M, et al. Tolerance of COVID-19 vaccination in patients with systemic lupus erythematosus: the international VACOLUP study. Lancet Rheumatol 2021;3
Izmirly P, Kim M, Samanovic M, et al. Evaluation of Immune Response and Disease Status in SLE Patients Following SARS-CoV-2 Vaccination. Arthritis rheumatol 2021 Published Online First: 4 Aug 2021. doi: 10.1002/art.41937
Lawson-Tovey S, Hyrich K, Gossec L, et al. SARS-CoV-2 infection after vaccination in patients with inflammatory rheumatic and musculoskeletal diseases. Ann Rheum Dis 2021 Published Online First: 6 Sep 2021. doi: 10.1136/annrheumdis-2021-221217
Medeiros-Ribeiro A, Aikawa N, Saad C, et al. Immunogenicity and safety of the CoronaVac inactivated vaccine in patients with autoimmune rheumatic diseases: a phase 4 trial. Nat Med 2021 Published Online First: 30 Jul 2021. doi: 10.1038/s41591-021-01469-5
Moyon Q, Sterlin D, Miyara M, et al. BNT162b2 vaccine-induced humoral and cellular responses against SARS-CoV-2 variants in systemic lupus erythematosus. Ann Rheum Dis 2021 Published Online First: 4 Oct 2021. doi: 10.1136/annrheumdis-2021-221097
Picchianti-Diamanti A, Aiello A, Laganà B, et al. Immunosuppressive Therapies Differently Modulate Humoral- and T-Cell- Specific Responses to COVID-19 mRNA Vaccine in Rheumatoid Arthritis Patients. Front Immunol 2021;12:740249.
Rotondo C, Cantatore F, Fornaro M, et al. Preliminary Data on Post Market Safety Profiles of COVID 19 Vaccines in Rheumatic Diseases: Assessments on Various Vaccines in Use, Different Rheumatic Disease Subtypes, and Immunosuppressive Therapies: A Two-Centers Study. Vaccines (Basel) 2021;9:730.
Rubbert-Roth A, Vuilleumier N, Ludewig B, et al. Anti-SARS-CoV-2 mRNA vaccine in patients with rheumatoid arthritis. Lancet Rheumatol 2021;3:e470-72.
Sattui S, Liew J, Kennedy K, et al. Early experience of COVID-19 vaccination in adults with systemic rheumatic diseases: results from the COVID-19 Global Rheumatology Alliance Vaccine Survey. RMD Open 2021;7:e001814.

Studies that did not pass quality assessment (Supplementary Table 1)

Abdellaoui S, Boukabous A, Bengana B, et al. Rheumatic diseases on COVID-19 era. *Int J Rheum Dis* 2020;23:3-108.
Abualfadl E, Ismail F, Shereef RRE, et al. Impact of COVID-19 pandemic on rheumatoid arthritis from a Multi-Centre patient-reported questionnaire survey: influence of gender, rural-urban gap and north-south gradient. *Rheumatol Int* 2021;41:345-53.
Aliyeva N, Yalçin Dulundu BÇ, Amikishiyev S, et al. POS1259 FAVOURABLE SHORT-TERM COURSE OF COVID-19 IN PATIENTS WITH FAMILIAL MEDITERRANEAN FEVER USING BIOLOGIC AGENTS. *Ann Rheum Dis* 2021;80:913-14.
Andreica I, Guminski B, Sokolar J, et al. [Threat of a SARS-CoV-2 endemic in a large hospital specialized in rheumatic diseases-relative all clear through consistent testing]. *Z Rheumatol* 2021;80:45–47.
Antovic A, Lövström B, Hugelius A, et al. POS1230 OUTCOME FOLLOWING COVID-19 INFECTION IN ANTI-NEUTROPHIL CYTOPLASMIC ANTIBODY (ANCA)-ASSOCIATED VASCULITIS. *Ann Rheum Dis* 2021;80:898-98.
Asif R, Elndari N, Negi A. POS1167 REVIEW OF THE IMPACT OF COVID-19 PANDEMIC ON RHEUMATOLOGY SERVICES AT A LARGE TERTIARY CARE CENTRE IN WALES, UK. *Ann Rheum Dis* 2021;80:862-63.
Banerjee S, George M, Young K, et al. Effects of the COVID-19 Pandemic on Patients Living With Vasculitis. *ACR Open Rheumatol* 2021;3:17-24.
Barbhaiya M, Vitone G, Frey M, et al. Characteristics of Rheumatology Outpatients with Suspected or Confirmed COVID-19 during the Pandemic in New York City. *Arthritis rheumatol* 2020;72:1-4259.
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 VDLD* 2020;37:e2020009.

Beketova TV, Babak VV, Suprun MD. The course and outcomes of Covid-19 in patients with anca-associated systemic vasculitis, receiving biological therapy (rituximab, mepolizumab): The results of the first 8 months of the pandemic. *Nauchno-Prakticheskaya Revmatologiya* 2021;59:37-46.
Bellan M, Parisi S, Stobbione P, et al. Impact of the COVID-19 outbreak on an Italian cohort of systemic sclerosis patients. *Scand J Rheumatol* 2020;49:505-06.
Briones-Figueroa A, Garcia-Villanueva MJ, Suarez AA, et al. Clinical Characteristics and Impact of the COVID-19 Pandemic in Systemic Lupus Erythematosus Patients in a Spanish Tertiary Hospital. *Arthritis rheumatol* 2020;72:Suppl 10.
Cacciapaglia F, Manfredi A, Erre G, et al. Correspondence on 'Characteristics associated with hospitalisation for COVID-19 in people with rheumatic disease: data from the COVID-19 global rheumatology alliance physician-reported registry' by Gianfrancesco M et al. The impact of cardiovascular comorbidity on COVID-19 infection in a large cohort of rheumatoid arthritis patients. *Ann Rheum Dis* 2020 Published Online First: 15 Sept 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218813
Carubbi F, Alunno A, Ferri C, et al. The Impact of SARS-CoV-2 Outbreak on Primary Sjogren's Syndrome: An Italian Experience. *Front Med (Lausanne)* 2020;7:608728.
Cheila MEAENDKKC. EP09 COVID-19 and rheumatic disease clinical characteristics and outcomes of rheumatic disease patients hospitalised with COVID-19: a single centre experience. *Rheumatology Advances in Practice* 2020;4:Suppl 1.
Chen C, Yao B, Yan M, et al. The Plight of Patients with Lupus Nephritis during the Outbreak of COVID-19 in Wuhan, China. *J Rheumatol* 2020;47:1452.
Cho J, Kandane-Rathnayake R, Louthrenoo W, et al. COVID-19 infection in patients with systemic lupus erythematosus: Data from the Asia Pacific Lupus Collaboration. *Int J Rheum Dis* 2020;23:1255-57.
Conticini E, Bargagli E, Bardelli M, et al. COVID-19 pneumonia in a large cohort of patients treated with biological and targeted synthetic antirheumatic drugs. *Ann Rheum Dis* 2021;80:e14.
Conway R, Nikiphorou E, Demetriou C, et al. POS1162 PREDICTORS OF HOSPITALISATION IN PATIENTS WITH RHEUMATIC DISEASE AND COVID-19 IN IRELAND: DATA FROM THE COVID-19 GLOBAL RHEUMATOLOGY ALLIANCE PHYSICIAN-REPORTED REGISTRY. *Ann Rheum Dis* 2021;80:859-60.
Costantino F, Bahier L, Tarancon LC, et al. COVID-19 in French patients with chronic inflammatory rheumatic diseases: Clinical features, risk factors and treatment adherence. *Joint Bone Spine* 2020;88:105095.
Dadalova A, Vasilenko E, Samigullina R, et al. AB0712 THE INCIDENCE OF SARS-COV-2 INFECTION IN PATIENTS WITH RHEUMATIC DISEASES ON THERAPY BIOLOGICAL DISEASE MODIFYING ANTIRHEUMATIC DRUGS. *Ann Rheum Dis* 2021;80:1387-88.
Del Papa N, Sambataro G, Minniti A, et al. Impact of COVID-19 outbreak in an Italian cohort of patients with systemic sclerosis. *Ther* 2020;12:1759720X20953356.
Desbois AC, Marques C, Lefevre L, et al. Prevalence and Clinical Features of COVID-19 in a Large Cohort of 199 Patients with Sarcoidosis. *Arthritis rheumatol* 2020;72:Suppl 10.
Domsic R, Chung L, Molitor J, et al. Clinical Outcomes Among Participants with Diffuse Systemic Sclerosis Contracting COVID-19 During Clinical Studies of Lenabasum: A Case Series. *Arthritis rheumatol* 2020;72:Suppl 10.
Espinosa G, Araujo O, Amaro S, et al. COVID-19 and Behcet's disease: clinical case series. *Ann Rheum Dis* 2020;80:e41.
Fasano S, Ciccia F. Incidence of COVID-19 in an Italian cohort of patients with systemic lupus erythematosus: an observational survey. *Clin Exp Rheumatol* 2021;39:13.
Fasano S, Pantano I, Mauro D, et al. POS1210 PREVALENCE OF COVID-19 AMONG PATIENTS WITH RHEUMATIC DISEASES: AN OBSERVATIONAL SURVEY DURING THE TWO WAVES IN ITALY. *Ann Rheum Dis* 2021;80:888-88.
Favalli EG, Bugatti S, Klersy C, et al. Impact of corticosteroids and immunosuppressive therapies on symptomatic SARS-CoV-2 infection in a large cohort of patients with chronic inflammatory arthritis. *Arthritis Res Ther* 2020;22:290.
Favalli EG, De Lucia O, Biggioggero M, et al. Role of antimalarials in COVID-19: observational data from a cohort of rheumatic patients. *Ann Rheum Dis* 2020;80:e75.
Favalli EG, Ingegnoli F, Cimaz R, et al. What is the true incidence of COVID-19 in patients with rheumatic diseases? *Ann Rheum Dis* 2021;80:e18.
Fayed F, Abdelkarim E. AB0654 TOCILIZUMAB IS PROTECTIVE AGAINST SARS-COV2 INFECTION OR NOT? *Ann Rheum Dis* 2021;80:1359-60.
Felten R, Scherlinger M, Kleinmann JF, et al. Prévalence du COVID-19 et des poussées inflammatoires chez les patients atteints de maladie auto-immunes systémiques rares : enquête systématique téléphonique et sérologique dans un centre national de référence. *Revue du Rhumatisme* 2020;87:A289-A89.

Fernandez-Avila D, Barahona-Correa J, Romero-Alvernia D, et al. How Did SARS-CoV2/COVID-19 Pandemic Affected Patients with Rheumatic Diseases in Latin America? A Regional Survey from PANLAR. *Arthritis rheumatol* 2020;72:Suppl 10.
Fernandez-Ruiz R, Masson M, Kim MY, et al. Leveraging the United States Epicenter to Provide Insights on COVID-19 in Patients With Systemic Lupus Erythematosus. *Arthritis rheumatol* 2020;72:1971-80.
Formenti AM, Pedone E, di Filippo L, et al. Are women with osteoporosis treated with denosumab at risk of severe COVID-19? *Endocrine* 2020;70:203-05.
Fredi M, Cavazzana I, Moschetti L, et al. COVID-19 in patients with rheumatic diseases in northern Italy: a single-centre observational and case-control study. *Lancet Rheumatol* 2020;2:e549-e56.
García Fernández A, Morán Álvarez P, Bachiller-Corral J, et al. POS1204 LOW POSITIVITY RATE IN ANTIBODY SARS-COV2 TESTS IN PATIENTS WITH RHEUMATIC DISEASES TREATED WITH RITUXIMAB. A CASE CONTROL STUDY OF A HIGH IMPACT SARS-COV2 INFECTION AREA. *Ann Rheum Dis* 2021;80:884-85.
García-Fernández A, Lopez-Gutierrez F, Loarce-Martos J, et al. Cohort of Rheumatic Patients Treated with Rituximab and COVID-19: Does Rituximab Treatment Increases the Severity of SARS-COV2 Infection? *Arthritis rheumatol* 2020;72:1287-90.
Garrido-Cumbrera M, Marzo-Ortega H, Correa-Fernandez J, et al. Assessment of the COVID-19 Pandemic from the Perspective of People with Rheumatic Musculoskeletal Diseases in Europe. Preliminary Results from the REUMAVID Study. *Arthritis rheumatol* 2020;72:Suppl 10.
Gazzaruso C, Carlo Stella N, Mariani G, et al. Impact of anti-rheumatic drugs and steroids on clinical course and prognosis of COVID-19. *Clin Rheumatol* 2020;39:2475-77.
Gendebien Z, von Frenckell C, Ribbens C, et al. Systematic analysis of COVID-19 infection and symptoms in a systemic lupus erythematosus population: correlation with disease characteristics, hydroxychloroquine use and immunosuppressive treatments. *Ann Rheum Dis* 2020;80:e94.
Gentry CA, Humphrey MB, Thind SK, et al. Long-term hydroxychloroquine use in patients with rheumatic conditions and development of SARS-CoV-2 infection: a retrospective cohort study. *Lancet Rheumatol* 2020;2:e689-e97.
George M, Venkatachalam S, Banerjee S, et al. Concerns and Health-Related Behaviors During the COVID-19 Pandemic in Patients with or Without Autoimmune Rheumatic Disease in a Large Physician Network. *Arthritis rheumatol* 2020;72:Suppl 10.
George MD, Venkatachalam S, Banerjee S, et al. Concerns, Healthcare Use, and Treatment Interruptions in Patients With Common Autoimmune Rheumatic Diseases During the COVID-19 Pandemic. *J Rheumatol* 2021;48:603-07.
Glintborg B, Jensen DV, Engel S, et al. Self-protection strategies and health behaviour in patients with inflammatory rheumatic diseases during the COVID-19 pandemic: results and predictors in more than 12 000 patients with inflammatory rheumatic diseases followed in the Danish DANBIO registry. *RMD Open* 2021;7:e001505.
Gonzalez C, Viso LAMROBA, A. Herranz RCL, et al. CO0003 TREATMENT WITH BIOLOGICAL THERAPIES AND RISK OF BEING ADMITTED TO THE HOSPITAL FOR COVID19 INFECTION. *Ann Rheum Dis* 2020;79:214-15.
Goyal M, Patil P, Pathak H, et al. Impact of COVID-19 pandemic on patients with SLE: results of a large multicentric survey from India. *Ann Rheum Dis* 2020;80:e71.
Günendi Z, Yurdakul FG, Bodur H, et al. The impact of COVID-19 on familial Mediterranean fever: a nationwide study. *Rheumatol Int* 2021;41:1447–55.
Hasseli R, Hoyer BF, Krause A, et al. OP0283 DOES TNF-INHIBITION DECREASE THE RISK OF SEVERE COVID-19 IN RMD-PATIENTS? *Ann Rheum Dis* 2021;80:171-72.
Hasseli R, Mueller-Ladner U, Hoyer BF, et al. Older age, comorbidity, glucocorticoid use and disease activity are risk factors for COVID-19 hospitalisation in patients with inflammatory rheumatic and musculoskeletal diseases. *RMD Open* 2021;7:e001464.
Hasseli R, Pfeil A, Hoyer BF, et al. Do patients with rheumatoid arthritis show a different course of COVID-19 compared to patients with spondyloarthritis? *Clin Exp Rheumatol* 2021;39:639-47.
Hausmann J, Kennedy K, Surangiwala S, et al. Characteristics of Adult Patients with Rheumatic Diseases During the COVID-19 Pandemic: Data from an International Patient Survey. *Arthritis rheumatol* 2020;72:Suppl 10.
Hoffmann-Vold AM, Brunborg C, Tirelli F, et al. POS0054 THE IMPACT AND OUTCOME OF COVID-19 ON SYSTEMIC SCLEROSIS PATIENTS FROM THE EUROPEAN SCLERODERMA TRIAL AND RESEARCH GROUP (EUSTAR). *Ann Rheum Dis* 2021;80:232-33.
Howren A, Avina-Zubieta JA, Rebic N, et al. Virtual rheumatology appointments during the COVID-19 pandemic: an international survey of perspectives of patients with rheumatic diseases. *Clin Rheumatol* 2020;39:3191-93.

Ince B, Bektas M, Koca N, et al. POS1257 HYPOGAMMAGLOBULINEMIA IS A SIGNIFICANT RISK FACTOR FOR MORTALITY IN PATIENTS WITH ANCA ASSOCIATED VASCULITIS AND COVID-19. *Ann Rheum Dis* 2021;80:912-13.
Islam N, Ara Rahman M, Uz Zaman A, et al. Frequency and characteristics of Covid-19 infection in rheumatic patients-an online survey from Bangladesh. *Int J Rheum Dis* 2020;23:171.
Isnardi CA, Quintana R, Roberts K, et al. POS1208 EPIDEMIOLOGY AND OUTCOMES OF PATIENTS WITH RHEUMATIC DISEASES AND SARS-CoV-2 INFECTION: DATA FROM THE ARGENTINEAN SAR-COVID REGISTRY. *Ann Rheum Dis* 2021;80:887.
Kalyoncu U, PehlIvan Y, Akar S, et al. Preferences of Inflammatory Arthritis Patients for Biological Disease-Modifying Antirheumatic Drugs in the First 100 Days of COVID-19 Pandemic. *Turk J Med Sci* 2021 Published Online First: 22 Feb 2021. doi: https://dx.doi.org/10.3906/sag-2012-5
Kant S, Morris A, Ravi S, et al. The impact of COVID-19 pandemic on patients with ANCA associated vasculitis. *J Nephrol* 2021;34:185–90.
Kharouf F, Eviatar T, Braun M, et al. POS1217 THE PATTERN OF COVID 19 PANDEMIC AMONG PATIENTS WITH AUTOIMMUNE INFLAMMATORY RHEUMATIC DISEASES (AIIRD). *Ann Rheum Dis* 2021;80:892.
Khoubnasabjafari M, Jouyban A, Malek Mahdavi A, et al. Prevalence of COVID-19 in patients with rheumatoid arthritis (RA) already treated with hydroxychloroquine (HCQ) compared with HCQ-naive patients with RA: a multicentre cross-sectional study. *Postgrad Med J* 2021 Published Online First: 13 Jan 2021. doi: https://dx.doi.org/10.1136/postgradmedj-2020-139561
Kipps S, Paul A, Vasireddy S. Incidence of COVID-19 in patients with rheumatic disease: is prior health education more important than shielding advice during the pandemic? *Clin Rheumatol* 2020;40:1575–79.
Koltsova E, Lukina G, Shmidt E, et al. AB0703 THE COURSE OF COVID-19 INFECTION IN PATIENTS WITH ARTHRITIS RECEIVING TARGETED DMARDS. *Ann Rheum Dis* 2021;80:1383-84.
Lahrichi S, Nassar K, Janani S. AB0662 IMPACT OF THE SARS-CoV-2 PANDEMIC IN A POPULATION OF PATIENTS FOLLOWED IN A RHEUMATOLOGY DEPARTMENT. *Ann Rheum Dis* 2021;80:1363.
Lin C, Wang Z, Li J, et al. Implications of SARS-CoV-2 infection for patients with rheumatic disease. *Ann Rheum Dis* 2020 Published Online First: 13 Aug 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218050
Loarce-Martos J, Garcia-Fernandez A, Lopez-Gutierrez F, et al. High rates of severe disease and death due to SARS-CoV-2 infection in rheumatic disease patients treated with rituximab: a descriptive study. *Rheumatol Int* 2020;40:2015-21.
Lohse A, Bossert M, Bozgan AM, et al. Frequency and severity of COVID-19 in patients treated with biological disease-modifying anti-rheumatic drugs for inflammatory rheumatic disease: a cross-sectional study. *Clin Exp Rheumatol* 2020;38:1273.
Lwin M, Holroyd C, Wallis D, et al. Does COVID-19 cause an increased risk of hospitalization or death in patients with inflammatory rheumatic diseases treated with biological DMARDs or targeted synthetic DMARDs? *Rheumatology Advances in Practice* 2020;4:rkaa061.
Mageau A, Aldebert G, Van Gysel D, et al. SARS-CoV-2 infection among inpatients with systemic lupus erythematosus in France: a nationwide epidemiological study. *Ann Rheum Dis* 2021;80:1101-02.
Mancuso CA, Duculan R, Jannat-Khah D, et al. Modifications in Systemic Rheumatic Disease Medications: Patients' Perspectives during the Height of the COVID-19 Pandemic in New York City. *Arthritis Care Res* 2020;73:909-17.
Marques C, Pinheiro MM, Reis Neto ET, et al. COVID-19 in patients with rheumatic diseases: what is the real mortality risk? *Ann Rheum Dis* 2020 Published Online First: 13 Jul 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218388
Marques CDL, Kakehasi AM, Pinheiro MM, et al. High levels of immunosuppression are related to unfavourable outcomes in hospitalised patients with rheumatic diseases and COVID-19: first results of ReumaCoV Brasil registry. *RMD Open* 2021;7:e001461.
Martínez-López D, Prieto-Peña D, Sanchez-Bilbao L, et al. POS1231 COVID-19 INFECTION IN RHEUMATIC IMMUNE-MEDIATED INFLAMMATORY DISEASES. EPIDEMIOLOGICAL STUDY IN A SINGLE UNIVERSITY HOSPITAL. *Ann Rheum Dis* 2021;80:899.
Martínez-Martínez MU, Irazoque-Palazuelos F, Rodriguez-Reyne TS, et al. POS1245 MORTALITY OF COVID-19 IN PATIENTS WITH RHEUMATIC DISEASES: COMPARISON TO THE GENERAL POPULATION IN MÉXICO. *Ann Rheum Dis* 2021;80:905-06.
Martire V, Airoldi C, Gálvez Elkin MS, et al. AB0689 INCIDENCE AND SEVERITY OF COVID-19 IN PATIENTS WITH SPONDYLOARTHRITIS IN ARGENTINA: EXPERIENCE IN A COUNTRY WITH STRICT ISOLATION. *Ann Rheum Dis* 2021;80:1377-78.

Mattioli I, Bettiol A, Urban ML, et al. POS1212 SARS-CoV-2 INFECTION AMONG PATIENTS WITH BEHÇET'S SYNDROME. *Ann Rheum Dis* 2021;80:889.
McKee P, Irvine A, Riddell C, et al. OP0265-HPR IMPACT OF COVID-19 PANDEMIC ON RHEUMATOLOGY PATIENTS IN NORTHERN IRELAND – A WEB BASED CROSS-SECTIONAL SURVEY. *Ann Rheum Dis* 2021;80:161-62.
Migkos MP, Kaltsonoudis E, Pelechas E, et al. Use of conventional synthetic and biologic disease-modifying anti-rheumatic drugs in patients with rheumatic diseases contracting COVID-19: a single-center experience. *Rheumatol Int* 2021;41:903-09.
Monov S, Shumnalieva R, Monova D. POS1184 AUTOIMMUNE SYSTEMIC DISEASES AND COVID-19 INFECTION. *Ann Rheum Dis* 2021;80:873.
Monti S, Balduzzi S, Delvino P, et al. Clinical course of COVID-19 in a series of patients with chronic arthritis treated with immunosuppressive targeted therapies. *Ann Rheum Dis* 2020;79:667-68.
Moradi S, Masoumi M, Mohammadi S, et al. Prevalence of coronavirus disease 2019 in rheumatic patients and evaluation of the effect of disease-modifying anti-rheumatic drugs. *Intern Emerg Med* 2020;16:919–23.
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;198:771-75.
Murray K, Quinn S, Turk M, et al. POS1216 SYMPTOM RATES, ATTITUDES AND MEDICATION ADHERENCE OF RHEUMATIC AND MUSCULOSKELETAL DISEASE PATIENTS DURING THE SARS-CoV2 PANDEMIC. *Ann Rheum Dis* 2021;80:891-92.
Nuño L, Novella Navarro M, Bonilla G, et al. Clinical course, severity and mortality in a cohort of patients with COVID-19 with rheumatic diseases. *Ann Rheum Dis* 2020;79:1659-61.
Opdam M, Benoy S, Verhoef LM, et al. POS1197 IN DEPTH IDENTIFICATION OF RISK FACTORS FOR SEVERE COVID-19, REQUIRING HOSPITALIZATION, IN PATIENTS WITH INFLAMMATORY RHEUMATIC DISEASES: RESULTS OF A DUTCH NESTED CASE CONTROL STUDY (PRELIMINARY RESULTS). *Ann Rheum Dis* 2021;80:880-81.
Pellegrino G, Mohammad Reza Beigi D, Angelelli C, et al. COVID-19 and systemic sclerosis: analysis of lifestyle changes during the SARS-CoV-2 pandemic in an Italian single-center cohort. *Clin Rheumatol* 2021;40:1393–97.
Quere B, Saraux A, Marhadour T, et al. Impact of the COVID-19 pandemic on therapeutic management of rheumatoid arthritis in Brittany (France). *Joint Bone Spine* 2021;88:105179.
Ramirez GA, Lanzillotta M, Ebbo M, et al. POS1247 CLINICAL FEATURES AND OUTCOMES OF COVID-19 IN PATIENTS WITH IGG4-RELATED DISEASE. A COLLABORATIVE EUROPEAN MULTI-CENTRE STUDY. *Ann Rheum Dis* 2021;80:907.
Reyes AA, Alle G, Tanten R, et al. POS1188 COVID-19 IN PATIENTS WITH RHEUMATIC DISEASES: COMPARISON OF DATA FROM THE ARGENTINE REGISTRY (SAR-COVID), WITH THE LATIN AMERICAN AND GLOBAL REGISTRY (GLOBAL RHEUMATOLOGY ALLIANCE). *Ann Rheum Dis* 2021;80:875-76.
Rosenbaum JT, Hamilton H, Choi D, et al. Biologics, spondylitis and COVID-19. *Ann Rheum Dis* 2020;79:1663-65.
Rosenbaum JT, Weisman MH, Shafer C, et al. Correspondence on 'Factors associated with COVID-19-related death in people with rheumatic diseases: results from the COVID-19 Global Rheumatology Alliance physician-reported registry'. *Ann Rheum Dis* 2021 Published Online First: 13 May 2021. doi: https://dx.doi.org/10.1136/annrheumdis-2021-220588
Roux CH, Brocq O, Gerald F, et al. Impact of Home Confinement During the COVID-19 Pandemic on Medication Use and Disease Activity in Spondyloarthritis Patients. *Arthritis rheumatol* 2020;72:1771-72.
Roux CH, Brocq O, Gerald F, et al. Clinical impact of COVID-19 on a French population of spondyloarthritis patients. *Clin Rheumatol* 2020;39:3185-87.
Saadoun D, Vieira M, Vautier M, et al. SARS-CoV-2 outbreak in immune-mediated inflammatory diseases: the Euro-COVIMID multicentre cross-sectional study. *Lancet Rheumatol* 2021;3:E481-E88.
Salviato Pileggi G, Ferreira G, Gomides AP, et al. POS1252 COVID-19 IN PATIENTS WITH RHEUMATIC DISEASES ON CHRONIC USE OF HYDROXYCHLOROQUINE IN A LARGE BRAZILIAN COHORT – A 24-WEEK PROSPECTIVE STUDY. *Ann Rheum Dis* 2021;80:909-10.
Santos CS, Morales CM, Alvarez ED, et al. Determinants of COVID-19 disease severity in patients with underlying rheumatic disease. *Clin Rheumatol* 2020;39:2789-96.
Sarzi-Puttini P, Marotto D, Caporali R, et al. Prevalence of COVID infections in a population of rheumatic patients from Lombardy and Marche treated with biological drugs or small molecules: A multicentre retrospective study. *J Autoimmun* 2021;116:102545.

Seyahi E, Poyraz BC, Sut N, et al. The psychological state and changes in the routine of the patients with rheumatic diseases during the coronavirus disease (COVID-19) outbreak in Turkey: a web-based cross-sectional survey. *Rheumatol Int* 2020;40:1229-38.
Shoop-Worrall S, Verstappen S, Costello W, et al. AB0681 HOW COMMON IS COVID-19 IN CHILDREN, YOUNG PEOPLE AND ADULTS WITH RHEUMATIC DISEASES? RESULTS FROM THE INTERNATIONAL COVID-19 EUROPEAN PATIENT REGISTRY. *Ann Rheum Dis* 2021;80:1373-74.
Singer ME, Kaelber DC, Antonelli MJ. Hydroxychloroquine ineffective for COVID-19 prophylaxis in lupus and rheumatoid arthritis. *Ann Rheum Dis* 2020 Published Online First: 05 Aug 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218500
Singh N, Huang I, Singleton M, et al. POS1422 CORRELATES OF TESTING POSITIVE FOR SARS-COV-2 IN PATIENTS WITH RHEUMATIC AD MUSCULOSKELETAL DISEASES. *Ann Rheum Dis* 2021;80:994.
Sirotich E, Semalulu T, Kennedy K, et al. Impact of the COVID-19 Pandemic on Racial and Ethnic Minority Groups Diagnosed with Rheumatic Diseases. *Arthritis rheumatol* 2020;72:Suppl 10.
Sorrentino L, Rebak J, Maldonado F, et al. POS1186 EFFECT OF SOCIO-ECONOMIC STATUS AND EDUCATIONAL LEVEL ON COVID-19 OUTCOMES IN PATIENTS WITH RHEUMATIC DISEASES FROM ARGENTINA: DATA FROM THE SAR-COVID REGISTRY. *Ann Rheum Dis* 2021;80:874-75.
Starovoytova M, Desinova O, Ananyeva LP, et al. POS1232 COVID-19 IN PATIENTS WITH SYSTEMIC SCLEROSIS: ONE RHEUMATOLOGY CENTER EXPERIENCE. *Ann Rheum Dis* 2021;80:899.
Tamartash Z, Javinani A, Gharibdoost F, et al. The clinical course of COVID-19 in systemic sclerosis patients, report from 150 patients. *Intern Emerg Med* 2021 Published Online First: 16 Apr 2021. doi: https://dx.doi.org/10.1007/s11739-021-02727-7
Tejada Cifuentes F, Lloret Callejo A, Tirado Pelaez MJ, et al. [Incidence of COVID-19 in patients under chronic treatment with hydroxychloroquine]. *Med Clin (Barc)* 2021;156:166-71.
Tomelleri A, Sartorelli S, Campochiaro C, et al. Impact of COVID-19 pandemic on patients with large-vessel vasculitis in Italy: a monocentric survey. *Ann Rheum Dis* 2020;79:1252-53.
Trandafir A, Saulescu I, Balanescu A, et al. AB0690 HOW DID COVID-19 AFFECT PATIENTS WITH RHEUMATIC AND MUSCULOSKELETAL DISEASES TREATED WITH DMARDs – EXPERIENCE FROM A ROMANIAN RHEUMATOLOGY HOSPITAL. *Ann Rheum Dis* 2021;80:1378.
Unlu Ozkan F, Sari K, Aktas I. POS1244 PRELIMINARY RESULTS OF LONG-TERM FOLLOW-UP OF THE HEALTH STATUS OF PATIENTS USING csDMARDs AND b/tsDMARDS FOR RHEUMATIC DISEASES DURING THE COVID-19 PANDEMIC. *Ann Rheum Dis* 2021;80:905.
Wan SA, Teh CL, Sachdev Manjit Singh B, et al. Clinical features of patients with rheumatic diseases and COVID-19 infection in Sarawak, Malaysia. *Ann Rheum Dis* 2020 Published Online First: 24 Jul 2020. doi: https://dx.doi.org/10.1136/annrheumdis-2020-218425
Wegrzyn L, Winthrop K, Kim S, et al. POS1207 REAL WORLD POPULATION-BASED ASSESSMENT OF COVID-19 OUTCOMES AMONG RHEUMATOID ARTHRITIS PATIENTS USING BIOLOGIC OR SYNTHETIC DMARDs. *Ann Rheum Dis* 2021;80:886.
Winthrop KL, Brunton AE, Beekmann S, et al. SARS CoV-2 infection among patients using immunomodulatory therapies. *Ann Rheum Dis* 2021;80:269-71.
Ye C, Zhong J, Cai S, et al. COVID-19 infection in patients with connective tissue disease: A multicity study in Hubei province, China. *MedComm (Beijing)* 2021;2:82-90.
Ye Y, Yue X, Krueger W, et al. POS1163 CHARACTERISTICS AND OUTCOMES IN A REAL-WORLD COHORT OF RHEUMATOID ARTHRITIS PATIENTS WITH COVID-19. *Ann Rheum Dis* 2021;80:860.
Yousefghahari B, Navari S, Sadeghi M, et al. Risk of COVID-19 infection in patients with rheumatic disease taking disease-modifying anti-rheumatic drugs. *Clin Rheumatol* 2021 Published Online First: 29 May 2021. doi: 10.1007/s10067-021-05779-4
Zhao J, Pang R, Wu J, et al. Clinical characteristics and outcomes of patients with COVID-19 and rheumatic disease in China 'hot spot' versus in US 'hot spot': similarities and differences. *Ann Rheum Dis* 2020;80:e63.
Ziadé N, El Kibbi L, Hmamouchi I, et al. Impact of the COVID-19 pandemic on patients with chronic rheumatic diseases: A study in 15 Arab countries. *Int J Rheum Dis* 2020;23:1550-57.
Zonozi R, Huizenga N, Charles R, et al. COVID-19 Recovery Without B Cells or Antibodies in Patients Receiving Rituximab for Autoimmune Disease. *Iran J Kidney Dis* 2021;1:159-60.
Zucchi D, Tani C, Elefante E, et al. Impact of first wave of SARS-CoV-2 infection in patients with Systemic Lupus Erythematosus: Weighting the risk of infection and flare. *PLoS ONE* 2021;16:e0245274.