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# Risk of new onset of immune-mediated diseases after SARS-CoV-2 infection: A systematic review and meta-analysis

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ABSTRACT

*Objectives:* The association between SARS-CoV-2 infection and new onset of immune-mediated diseases is of interest given the conflicting evidence. This study aims to gather evidence and estimate the risk of immune-mediated diseases following SARS-CoV-2 infection.
*Methods:* Analytical observational studies reporting immune-mediated diseases after confirmed SARS-CoV-2 infection, compared to individuals without infection history, were included. Thirty-nine immune-mediated diseases were defined as outcomes of interest. Studies including diagnosis within the first 30 days post-infection were excluded. PubMed, EMBASE, CINAHL, Web of Science, and Europe PMC were consulted. Relative risks were pooled using a random-effects model and the Mantel-Haenszel method.
*Results:* Eight studies met the eligibility criteria. Meta-analyses were conducted for 13 outcomes of interest from six studies. The SARS-CoV-2 exposed group exhibited significantly higher risks for 11 conditions compared to non-exposed group: Behçet's disease, spondyloarthritis, systemic sclerosis, systemic lupus erythematosus, polymyalgia rheumatica, psoriasis, rheumatoid arthritis, Sjögren's syndrome, type 1 diabetes (in adults), vasculitis, and inflammatory bowel disease. The range of the associations varied between 2.31 (95 % CI: 1.87–2.85) for systemic sclerosis to 3.71 (95 % CI: 1.18–11.72) for Behçet's disease. Guillain-Barré syndrome and type 1 diabetes (in the paediatric population) showed no evidence of association with SARS-CoV-2 infection.
*Conclusion:* Our results support a higher risk of developing at least 11 immune-mediated diseases evaluated. As autoimmunity is a hallmark of post-COVID-19 syndrome, an increase in these diseases may be expected in the future. Healthcare professionals and stakeholders should prioritize research and public health surveillance based on these findings.

## Introduction

There is a concern about the potential development of immune-mediated diseases following SARS-CoV-2 infection, the virus responsible for the disease known as COVID-19. Several reports and studies have suggested that viral infection can trigger autoimmune responses, potentially increasing the risk of immune-mediated diseases [1].

In some individuals with immune-mediated diseases, a subclinical process persists, where symptoms are discrete or absent, often delaying the diagnosis of the disease [2]. Additionally, many COVID-19 symptoms can mimic nonspecific manifestations of immune-mediated diseases [3,4], which might lead to seeking medical attention and consequently diagnosing pre-existing immune-mediated diseases. In such cases, the association between SARS-CoV-2 infection and the onset

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of an immune-mediated disease might appear causal due to the temporal sequence of events, when they could be independent pathological processes, a bias known as protopathic bias [5].

To the best of our knowledge, although systematic reviews on case reports of newly onset of immune-mediated diseases associated with SARS-CoV-2 infection have been published [6,7], none of them have included analytic studies or either considered the protopathic bias, which could overestimate the actual risk.

Based on the increasing interest in autoimmune manifestations following SARS-CoV-2 infection, we conducted a systematic review and meta-analysis aiming to estimate the risk of new onset of a set of immune-mediated diseases in individuals with confirmed SARS-CoV-2 infection compared to individuals with no history of infection.

## Methods

### *Search strategy and selection criteria*

This systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [8]. PROSPERO (CRD42023472446).

We considered analytical observational studies, including cross-sectional studies, case-control studies, and cohort studies in individuals of any gender or age, which reported the incidence or development of newly diagnosed immune-mediated diseases following a confirmed SARS-CoV-2 infection, compared to the incidence in individuals without history of the infection. No language or publication date restrictions were applied. Conference abstracts, case reports, case series, reviews, and studies not available in full text were excluded.

For this review, the SARS-CoV-2 infection was defined as the identification of the virus through positive nucleic acid amplification test or antigen test for SARS-CoV-2, and the index date for classifying a patient as exposed corresponds to the documented date of the positive test or the date of confirmation based on codes indicating a confirmed SARS-CoV-2 infection (e.g., ICD-10 U07.1). Studies that included individuals with self-reported infections without clinical evidence were excluded.

The primary outcome was the diagnosis of newly developed immune-mediated diseases 30 or more days after a confirmed SARS-CoV-2 infection supported by the recording or documentation of diagnostic classification codes or medical concepts based on clinical, paraclinical, or imaging findings, as reported in each study. With the intention of reducing the risk of protopathic bias, studies that included patients with an immune-mediated disease diagnosis within the first 30 days after infection were excluded as they could potentially indicate prior immune-mediated disease rather than a new event after infection.

Immune-mediated diseases of interest included: rheumatoid arthritis (RA), systemic lupus erythematosus (SLE), vasculitis, giant cell arteritis, polyarteritis nodosa, Takayasu arteritis, Behçet's disease, Cogan's syndrome, Buerger's disease, Sjögren's syndrome, systemic sclerosis, ankylosing spondylitis, idiopathic inflammatory myopathy, polymyalgia rheumatica, autoimmune hepatitis, primary sclerosing cholangitis, primary biliary cholangitis, multiple sclerosis, Graves' disease, psoriatic arthritis, Guillain-Barré syndrome, Still's disease, juvenile arthritis, Kawasaki disease, primary membranous glomerulopathy, vitiligo, alopecia areata, inflammatory bowel disease (IBD), autoimmune pancreatitis, glomerular membrane disease, autoimmune hemolytic anemia, nervous system autoimmune diseases, IgA glomerulonephritis, IgG4-related disease, type 1 diabetes mellitus (T1DM), bullous skin diseases, undifferentiated connective tissue diseases, psoriasis, and autoimmune thyroid disease.

Searches were conducted on June 27th, 2023, in PubMed, EMBASE, CINAHL, and Web of Science (Appendix Table A1). A semi-structured search was also conducted in the Europe PMC database for pre-prints. Relevant information was sought on the websites of the Centers for Disease Control and Prevention (CDC), the European Centre for Disease Prevention and Control (ECDC), and the United Kingdom Health Security Agency (UKHSA). In addition, the reference lists of all relevant articles identified through structured searches were examined.

The selection of studies was carried out by four reviewers organized into two groups using the online systematic review tool, Rayyan [9]. Each team independently and blindly reviewed 50 % of the articles based on their titles and abstracts. Articles that were not excluded during this phase were retrieved in full text for a detailed evaluation by the reviewers. Any discrepancies during the process were resolved through consensus or with the involvement of an additional reviewer.

### *Data analysis*

The data extraction process for each of the selected articles was independently conducted by two reviewers using Microsoft Excel (Office 365) by completing a pre-designed data form.

The extracted data included the following: study characteristics (author, year, country, funding source, design, publication date, execution date); population characteristics (eligibility criteria, sample size, comparator type, demographic data including age, gender, ethnicity, comorbidities, and follow-up); SARS-CoV-2 infection characteristics (diagnostic method, variant, date of SARS-CoV-2 infection, severity, symptoms), vaccination status; outcomes (as explained earlier, including incidence rates, cumulative incidences, etc.); association metric and their corresponding confidence or credibility intervals for each condition of interest.

Efforts were made to contact the authors of studies that were eligible for inclusion in the meta-analysis but did not fully report the results, requesting any relevant statistical data that was not presented in the published report.

The quality of each selected study was independently assessed by two reviewers using the Risk-of-Bias In Non-Randomized Studies of Exposure (ROBINS-E) tool [10]. This tool covers seven domains of risk of bias related to: 1) confounding; 2) measurement of exposure; 3) selection of participants into the study or into the analysis; 4) post-exposure interventions; 5) missing data; 6) measurement of the outcome; and 7) selection of the reported result and each of these domains and overall risk of bias were rated as low risk of bias, some concerns, high risk of bias, or very high risk of bias. Any discrepancies were resolved through consensus or by involving an additional reviewer. The potential for publication bias was explored by funnel plots.

A narrative synthesis was conducted to summarize the characteristics of each study, and specific outcome measurements for each immune-mediated disease were reported through a descriptive analysis, according to the association metric reported in the individual studies.

The grouped relative risks (RR) and their corresponding 95 % confidence intervals (95 % CI) were estimated to assess the risk of each of the pre-specified immune-mediated conditions if at least two studies were selected for that outcome. The combined number of events and the total number reported in the studies were used for this purpose. Both the random-effects model and the Mantel-Haenszel method were employed to estimate the overall effect. The $I^2$ statistic was calculated to assess heterogeneity among the studies. All statistical analyses were conducted using R software version 4.3.1.

A sensitivity analysis was conducted to assess the robustness of the findings and to evaluate the potential influence of follow-up duration on outcome identification. For this purpose, the quantitative synthesis was restricted to studies that applied a minimum follow-up period of $\geq$90 days after SARS-CoV-2 infection. This approach aims to exclude events potentially related to the acute or subacute phase of the disease and to focus on truly incident and delayed immune-mediated outcomes. The results of this analysis were compared with those of the main meta-analysis to identify potential changes in the magnitude or direction of the associations.

## Results

From the searches conducted in the previously defined resources, 6280 records were identified, including 2331 duplicates. After screening by titles and abstracts, 3916 records were excluded. Thirty-three records were assessed in full text. Seven studies met the eligibility criteria, and an additional record was found in the reference lists of selected studies, resulting in the inclusion of 8 papers. Fig. 1 provides an overview of the study selection process. The list of excluded studies and their reasons for exclusion can be found in Appendix Table A2.

### *Study characteristics*

Three of the selected studies were conducted in the US [11–13], one in the Middle East region (Israel) [14], and the others in Europe [15–18]. In all cases, these were population-based studies or clinical and administrative records with large sample sizes (Table 1).

Five out of eight studies were matched to balance baseline characteristics of the groups. In all cases, matches were made based on age and sex [11,12,14,17,18]. Three studies also matched by the index exposure date [12,14,18]; two studies by comorbidities or prevalent diseases [11, 17], and other two by vaccination status [14,18]. Some considered other matching variables such as race, socioeconomic status, lifestyle-related proxy variables [11], and healthcare utilization [17].

The shortest follow-up period to assess the outcome was 30 days [11]. In one study, the results are presented according to two-time intervals (30 to 180 and 180 to 360 days after the infection) [14].

Two studies estimated Incidence Rate Ratios (IRRs) to determine the association [15,17]; while six estimated Hazard Ratios (HRs) [11–14,16, 18].

### *Quality of assessment*

Given that 100 % ($n = 8$) of the studies generated at least one concern of bias in any of the 7 domains evaluated using the ROBINS-E tool, a general moderate risk was assigned (Table A3 of the Appendix).

Bias due to participant selection, bias due to outcome measurement, and bias due to missing data were domains judged as "low risk" in all 8 included studies [11,18].

Bias due to confounding factors was judged as high risk in three of the included studies due to significant uncontrolled confounding factors, one study did not consider comorbidities [15], and the other two did not take vaccination status into account [12,16].

Measurement of exposure, post-exposure interventions, and reported outcomes were domains judged with "some concerns" in three [12,13, 17], seven [11–13,15–18], and eight [11–18] of the included studies, respectively. The reason for assigning this level of risk in exposure measurement was due to the definition of the unexposed group being determined solely by the absence of COVID-19-related diagnostic codes; In this context, patients infected with SARS-CoV-2 without a documented COVID-19 diagnosis or with diagnoses lacking laboratory confirmation could have been misclassified. In the case of post-exposure interventions, the risk level was assigned due to the likelihood of interventions (reported or unknown) that could have been influenced by exposure during the follow-up period, including vaccination or other COVID-19-related interventions. Finally, in the domain of reported outcomes, the reason was that there was no evidence of an accessible protocol that described in detail the predefined analysis plan of each study.

The assessment of the risk of publication bias was not conducted due to the low power of funnel plots and asymmetry tests to distinguish between true asymmetry and random variability when the number of studies is small.

### *Results of individual studies*

In total, 31 outcomes of interest for this review were assessed in at least one of the 8 included studies. Table 2 presents the reported results for each outcome by study, according to the association metric used.

Systemic sclerosis, Behcet's disease, spondyloarthritis (ankylosing spondylitis), RA, polymyalgia rheumatica, psoriasis, Sjögren's syndrome, and SLE were evaluated in two studies [11,17], as was Guillain-Barré syndrome [14,17], while T1DM was evaluated in six studies [11,12,15–18]. The remaining immune-mediated diseases were

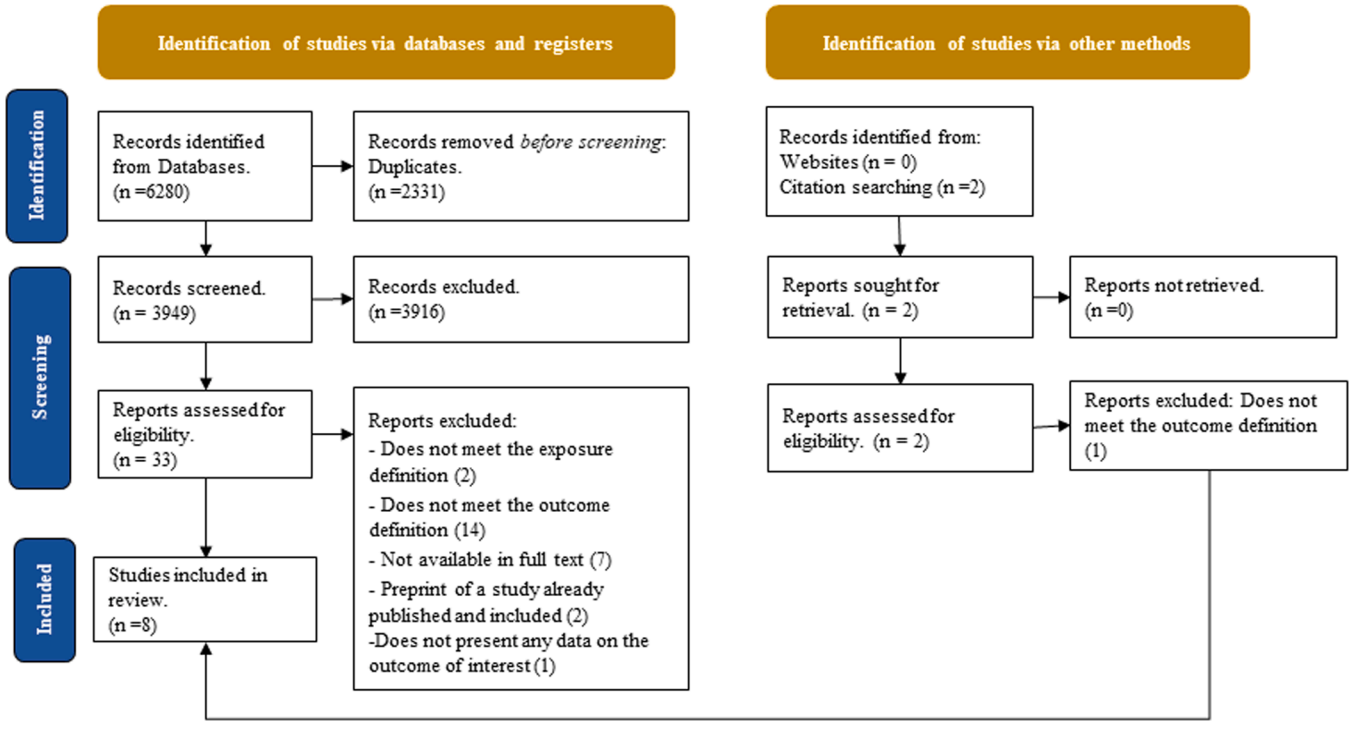


**Fig. 1.** Study flow diagram summarising the results of the literature search.

**Table 1**
Characteristics of the selected studies.

| ID Study, year. Country | Design, n | Setting | Comparisons | Follow-up period |
|---|---|---|---|---|
| Chang, 2023. US [11] | Matched cohort study (1:1), EG= 887,455 CG= 887,455 | US Collaborative Network from 48 global healthcare organizations in the TriNetX Research Network | Adults with positive PCR test for SARS-CoV-2 vs who tested negative and were not diagnosed with COVID-19 throughout the follow-up period | 30 days after the index - 6 months |
| Kompaniyets, 2022. US [12] | Matched cohort study (1:3), EG= 396,336 CG= 792,672 | CDC-licensed HealthVerity, Inc. medical claims data linked to SARS-CoV-2 commercial laboratory data | Patients aged 0–17 years with laboratory-confirmed COVID-19 vs patients aged 0–17 without recognized COVID-19 | For a minimum of 60 days and a maximum of 365 days or until January 31st, 2022 |
| McKeigue et al., 2023. Scotland [15] | Cohort study EG= 365,080 CG= 1484,331 | National register in Scotland linked (SC Diabetes registry, Electronic Communication of Surveillance in Scotland database) | Individuals aged <35 years who had been diagnosed with COVID-19 vs individuals aged <35 years who did not have COVID-19 | From March 1st, 2020, to November 22th 2021 |
| Mizrahi et al., 2023. Israel [14] | Matched cohort study (1:1), EG= 162,853 CG= 162,853 | Electronic medical records from an Israeli nationwide healthcare organization | Children and adults with a first positive PCR test for SARS-CoV-2 vs children and adults with a negative PCR test and no previous positive PCR test | From 30 days to the 12th month after the PCR test. Results: 30–180 days180–360 days |
| Noorzae et al., 2023. Denmark [16] | Cohort study EG= 720,592 CG= 1044,727 | Nationwide register Denmark (The Danish Civil Registration System, national COVID-19 surveillance system) | Residents aged 0 to 17 years with a positive SARS-CoV-2 test vs residents aged 0 to 17 years with only negative test results | 30 days after the first test positive until the end of the study, 18th birthday, death, emigration, or first diagnosis of T1DM or ketoacidosis. |
| Tesch et al., 2023. Germany [17] | Matched cohort study (1:3), EG= 641,407 CG= 1907,992 | German statutory health insurances | Children and adults with PCR-confirmed COVID-19 diagnosis (ICD-10 U07.1) in 2020 vs children and adults who were not diagnosed with ICD-10 U07.1 or ICD-10 U07.2 without a documented COVID-19 diagnosis | 3 to 15 months after documented COVID-19 infection |
| Xu et al., 2022. US [13] | Cohort study EG= 154,068 CG= 5638,795 | Electronic healthcare databases of the US Department of Veterans Affairs | Adults' users of the VHA in 2019 and positive COVID-19 test vs users of the VHA in 2019 alive by March 1st, 2020, and were not already part of the COVID-19 cohort | From 31 days after positive test until the end of follow (12 months) |
| Zareini et al., 2023. Denmark [18] | Matched cohort study (1:3), EG= 338,670 CG= 1004,688 | Health and administrative databases from several Denmark nationwide registries | Residents aged <30 testing positive for SARS-CoV-2 vs residents aged <30 not yet having tested positive for SARS-CoV-2 | On day 31 after index, to the date of T1DM, death, or end of study. |

CG: Control group, EG: Exposure group, PCR: Polymerase Chain Reaction T1DM: Type 1 Diabetes Mellitus, VHA: Veterans Health Administration.

each addressed in a single study.

According to the results reported in the individual studies included (Table 2), systemic sclerosis, SLE, Guillain-Barré syndrome, and T1DM show contradictory evidence regarding the association between the new onset of the disease and SARS-CoV-2 infection, while autoimmune hemolytic anaemia, primary biliary cholangitis, myasthenia gravis, blistering skin diseases (bullous pemphigoid), and autoimmune hepatitis have not been found to be associated with the infection. All other outcomes of interest reported in the included studies show a significantly higher risk for participants with a history of previous infection.

### *Synthesis of results*

Out of the 31 outcomes studied, only 13 had more than one study available for pooled analysis. The necessary information to conduct the combined analyses came from 6 out of the 8 included studies. Fig. 2 reports the results of statistical combinations from for each of these 13 outcomes including Behcet's disease, spondyloarthritis, systemic sclerosis, SLE, polymyalgia rheumatica, psoriasis, Sjögren's syndrome, RA, Guillain-Barré syndrome, T1DM in general population and T1DM in paediatric population, IBD and vasculitis.

Systemic sclerosis and (SLE), exhibited mixed evidence in original studies [11,17], but were significantly associated with SARS-CoV-2 infection in the pooled analysis (RR:3.21, 95 % CI: 1.87–2.85 and RR:3.17, 95 % CI: 2.25–4.48, respectively).

The same two studies contributed with information for Behcet's disease, spondyloarthritis, polymyalgia rheumatica, psoriasis, Sjögren's syndrome, and RA showing a positive association. The pooled estimates higher in this group were: Behcet's disease (RR: 3.71; 95 % CI:1.17–11.72), spondyloarthritis (RR: 3.50; 95 % CI: 2.59- 4.73) and RA (RR: 3.41; 95 % CI:2.24–5.19) (Fig. 2).

Three studies reported the risk of Guillain-Barré following SARS-

**Table 2**
Results of reported new onset of immune-mediated diseases after 30 days of a confirmed SARS-CoV-2 infection.

| Outcome | Study | No. Participants | | No. Events | | Follow -up[1] | Cumulative Incidence per 10,000 | | Central Estimate (HR or IRR) | 95 % CI |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Exp. | Non Exp. | Exp. | Non Exp. | | Exp. | Non Exp. | | |
| Alopecia areata | Tesch, 2023 | 641,407 | 1907,992 | 198 | 152 | 3 to15 m | 30.87 | 7.97 | 1.30* | 1.05–1.61 |
| Ankylosing spondylitis | Chang, 2023 | 887,455 | 887,455 | 243 | 82 | 1 to 6 m | 27.38 | 9.24 | 3.21§ | 2.50–4.13 |
| | Tesch, 2023 | 641,407 | 1907,992 | 263 | 194 | 3 to15 m | 41.00 | 10.17 | 1.36* | 1.13–1.63 |
| Autoimmune hemolytic anemia | Tesch, 2023 | 641,407 | 1907,992 | 21 | 15 | 3 to15 m | 3.27 | 0.79 | 1.37* | 0.71–2.65 |
| Autoimmune hepatitis | Tesch, 2023 | 641,407 | 1907,992 | 38 | 35 | 3 to15 m | 5.92 | 1.83 | 1.10* | 0.69–1.74 |
| Behcet's disease | Chang, 2023 | 887,455 | 887,455 | 45 | 21 | 1 to 6 m | 5.07 | 2.37 | 2.32§ | 1.38–3.89 |
| | Tesch, 2023 | 641,407 | 1907,992 | 21 | 9 | 3 to15 m | 3.27 | 0.47 | 2.42* | 1.10–5.35 |
| Bullous pemphigoid | Tesch, 2023 | 641,407 | 1907,992 | 45 | 29 | 3 to15 m | 7.02 | 1.52 | 1.54* | 0.97–2.46 |
| Crohn's disease | Tesch, 2023 | 641,407 | 1907,992 | 298 | 235 | 3 to15 m | 46.46 | 12.32 | 1.27* | 1.07–1.50 |
| Dermatopolymyositis | Chang, 2023 | 887,455 | 887,455 | 131 | 72 | 1 to 6 m | 14.76 | 8.11 | 1.96§ | 1.47–2.61 |
| Encephalitis or encephalopathy | Xu, 2022 | 154,068 | 5638,795 | - | - | 1 to 12 m | - | - | 1.82§ | 1.16–2.84 |
| Graves' disease | Tesch, 2023 | 641,407 | 1907,992 | 1696 | 1207 | 3 to15 m | 264.42 | 63.26 | 1.41* | 1.31–1.51 |
| Giant cell arteritis | Tesch, 2023 | 641,407 | 1907,992 | 53 | 33 | 3 to15 m | 8.26 | 1.73 | 1.63* | 1.05–2.53 |
| Granulomatosis with polyangiitis | Tesch, 2023 | 641,407 | 1907,992 | 41 | 16 | 3 to15 m | 6.39 | 0.84 | 2.51* | 1.42–4.46 |
| Guillain-Barré syndrome | Mizrahi, 2023a | 162,853 | 162,853 | 11 | 11 | 1 to 6 m | 6.75 | 6.75 | 1.12§ | 0.48–2.63 |
| | Mizrahi, 2023b | 150,609 | 150,609 | 7 | 3 | 6 to 12 m | 4.65 | 1.99 | 2.90§ | 0.72–11.78 |
| | Tesch, 2023 | 641,407 | 1907,992 | 20 | 9 | 3 to15m | 3.12 | 0.47 | 2.14* | 0.99–4.66 |
| | Xu, 2022 | 154,068 | 5638,795 | - | - | 1 to 12 m | - | - | 2.16§ | 1.40–3.35 |
| Hashimoto thyroiditis | Tesch, 2023 | 641,407 | 1907,992 | 2089 | 1474 | 3 to15m | 325.69 | 77.25 | 1.42* | 1.33–1.52 |
| Inflammatory bowel disease | Chang, 2023 | 887,455 | 887,455 | 7945 | 4863 | 1 to 6 m | 895.26 | 547.97 | 1.78§ | 1.72–1.84 |
| Mixed connective tissue disease | Chang, 2023 | 887,455 | 887,455 | 139 | 48 | 1 to 6 m | 15.66 | 5.41 | 3.14§ | 2.26–4.36 |
| Multiple sclerosis | Tesch, 2023 | 641,407 | 1907,992 | 271 | 226 | 3 to15m | 42.25 | 11.84 | 1.20* | 1.01–1.43 |
| Myasthenia gravis | Tesch, 2023 | 641,407 | 1907,992 | 41 | 27 | 3 to15m | 6.39 | 1.42 | 1.50* | 0.93–2.44 |
| Polymyalgia rheumatica | Chang, 2023 | 887,455 | 887,455 | 330 | 123 | 1 to 6 m | 37.18 | 13.86 | 2.90§ | 2.36–3.57 |
| | Tesch, 2023 | 641,407 | 1907,992 | 287 | 233 | 3 to15m | 44.75 | 12.21 | 1.24* | 1.04–1.47 |
| Primary biliary cirrhosis | Tesch, 2023 | 641,407 | 1907,992 | 40 | 32 | 3 to15m | 6.24 | 1.68 | 1.24* | 0.78–1.97 |
| Psoriasis | Chang, 2023 | 887,455 | 887,455 | 1967 | 734 | 1 to 6 m | 221.65 | 82.71 | 2.91§ | 2.67–3.17 |
| | Tesch, 2023 | 641,407 | 1907,992 | 1519 | 1299 | 3 to15m | 236.82 | 68.08 | 1.17* | 1.09–1.26 |
| Rheumatoid arthritis | Chang, 2023 | 887,455 | 887,455 | 2878 | 1044 | 1 to 6 m | 324.30 | 117.64 | 2.98§ | 2.78–3.20 |
| | Tesch, 2023 | 641,407 | 1907,992 | 1175 | 826 | 3 to15m | 183.19 | 43.29 | 1.42* | 1.30–1.56 |
| Sjögren's syndrome | Chang, 2023 | 887,455 | 887,455 | 727 | 301 | 1 to 6 m | 81.92 | 33.92 | 2.62§ | 2.29–3.00 |
| | Tesch, 2023 | 641,407 | 1907,992 | 604 | 419 | 3 to15m | 94.17 | 21.96 | 1.44* | 1.27–1.63 |
| Systemic lupus erythematosus | Chang, 2023 | 887,455 | 887,455 | 1189 | 429 | 1 to 6 m | 133.98 | 48.34 | 2.99§ | 2.68–3.34 |
| | Tesch, 2023 | 641,407 | 1907,992 | 63 | 47 | 3 to15m | 9.82 | 2.46 | 1.34* | 0.92–1.95 |
| Systemic sclerosis | Chang, 2023 | 887,455 | 887,455 | 222 | 93 | 1 to 6 m | 25.02 | 10.48 | 2.58§ | 2.02–3.28 |
| | Tesch, 2023 | 641,407 | 1907,992 | 35 | 50 | 3 to15m | 5.46 | 2.62 | 0.70* | 0.45–1.08 |
| Transverse myelitis | Xu, 2022 | 154,068 | 5638,795 | - | - | 1 to 12 m | - | - | 1.49§ | 1.11–2.00 |
| Type 1 diabetes mellitus | Chang, 2023 | 887,455 | | 3263 | 1318 | 1 to 6 m | 367.68 | 148.51 | 2.68§ | 2.51–2.85 |
| | McKeigue, 2023 | 36,508 | 1484,331 | 38 | 1005 | 1 to 20 m 21d | 104.09 | 67.71 | 0.86* | 0.62–1.21 |
| | Tesch, 2023 | 641,407 | 1907,992 | 381 | 304 | 3 to15 m | 59.40 | 15.93 | 1.25* | 1.08–1.46 |
| | Zareini, 2023 | - | - | 19 | 83 | - | 5.61 | 8.26 | 0.69§ | 0.42–1.13 |
| Type 1 diabetes mellitus (pediatric) | Kompaniyets, 2022 | 396,336 | 792,672 | 349 | 641 | 1 to 12 m | 88.06 | 80.87 | 1.10§ | 0.96–1.25 |
| | Noorzae, 2023 | 720,592 | 1044,727 | 144 | 469 | 1 to 28 m 24d | 19.98 | 44.89 | 0.85§ | 0.70–1.04 |
| Ulcerative colitis | Tesch, 2023 | 641,407 | 1907,992 | 367 | 282 | 3 to15 m | 57.22 | 14.78 | 1.30* | 1.12–1.52 |
| Vasculitis | Chang, 2023 | 887,455 | 887,455 | 800 | 444 | 1 to 6 m | 90.15 | 50.03 | 1.96§ | 1.74–2.20 |
| Vitiligo | Tesch, 2023 | 641,407 | 1907,992 | 132 | 97 | 3 to15 m | 20.58 | 5.08 | 1.36* | 1.05–1.77 |

Exp. = Exposed; Non Exp = Non Exposed; * = Hazard Ratio (HR); § = Incidence Rate Ratio (IRR); 95 % CI = 95 % Confidence Interval, *m* = months, *d*=days. 1: After COVID-19 infectio.

CoV-2 infection; however, only two provided the necessary data for combined estimates [14,17]. The pooled estimate indicated insufficient statistical evidence to support an association (RR: 2.88; 95 % CI: 0.58–14.35).

Finally, five of the six selected studies provided information for the combined analysis of T1DM [11,12,15–17], with two focused on pediatric population [12,16]. The combined analysis of the two pediatric studies did not show an excess risk after documented SARS-CoV-2 infection (RR: 0.70; 95 % CI:0.29–1.68). Whereas T1DM in the general population was found significantly associated with pooled estimates from three studies (RR: 2.46; 95 % CI:1.51- 4.00).

Additionally, since one of the selected studies reported on Crohn's disease and ulcerative colitis [17], and another study on the risk of overall IBD [11], a pooled analysis for overall IBD was conducted finding a positive association (RR: 2.50 95 % CI: 1.08–5.75). Similarly for vasculitis, we combined the result from a study reporting GPA and GCA [17], with one reporting on vasculitis in general (ICD-10 code M30–31 or L95) [11]; the pooled estimate for vasculitis was statistically associated with SARS-CoV-2 infection (RR: 3.17 95 % CI: 1.02- 9.80) (Table 2).

The range of heterogeneity, measured as $I^2$, ranged between 69.5 % and 99.4 %. Although subgroup analysis was planned in the review

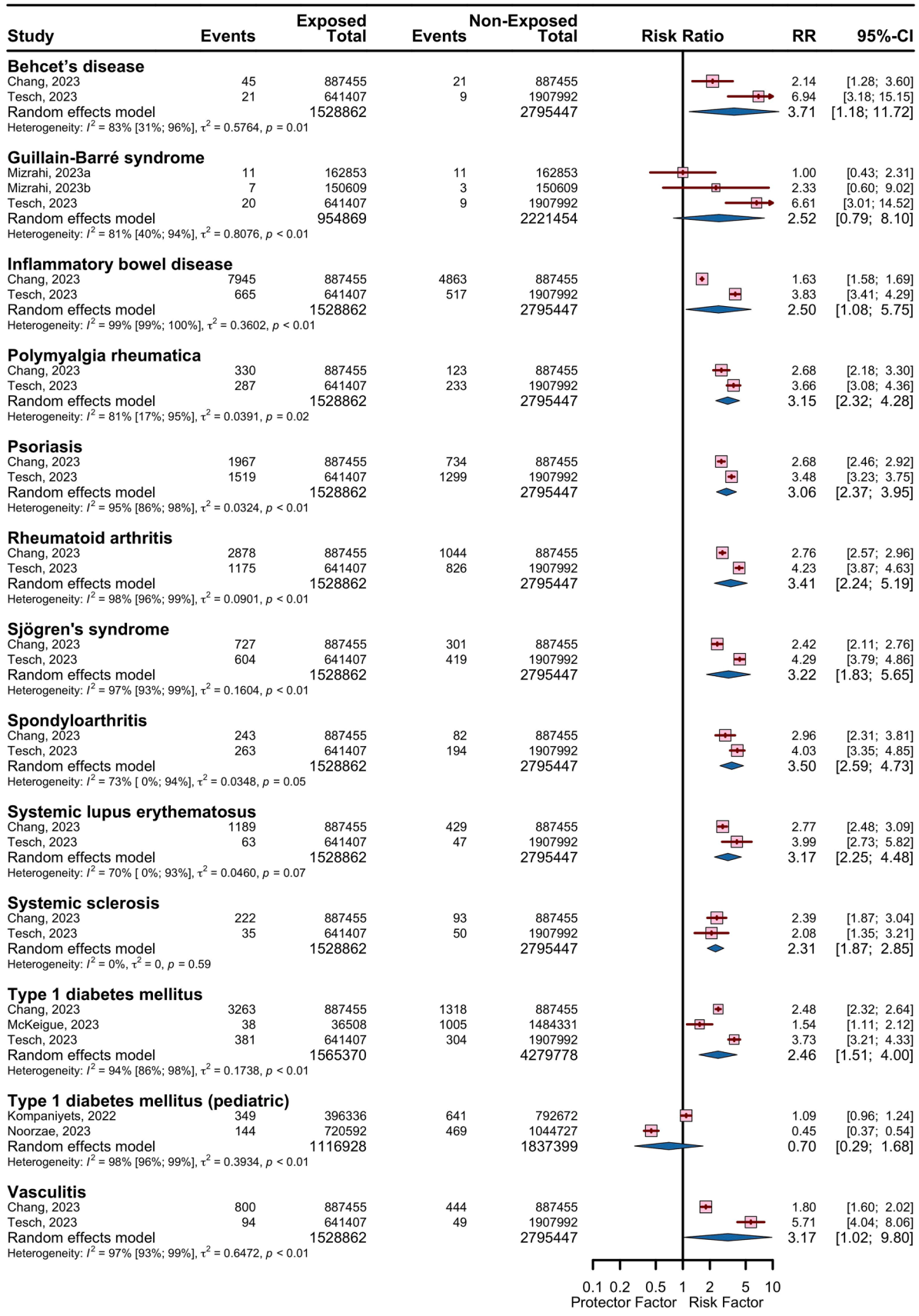


**Fig. 2.** Forest plot random effects meta-analysis of risk of new onset of immune-mediated diseases after SARS-CoV-2 infection.
footnote: RR: Relative risk, CI: Confidence interval.

protocol, it was not possible to conduct as all the studies included had already been matched by different confounding variables.

Sensitivity analysis. In the sensitivity analysis restricted to studies with a minimum follow-up of ≥90 days after SARS-CoV-2 infection, the only outcome with available data was Guillain-Barré syndrome. In this case, a positive and statistically significant association was identified between infection and disease onset (random-effects model: RR = 4.57; 95 % CI: 1.72–12.13; p = 0.0023). Heterogeneity between studies was moderate ($I^2$ = 41.2 %; p for heterogeneity = 0.1921).

## Discussion

In this systematic review and meta-analysis, we identified higher risk of new onset for 11 outcomes of immune-mediated diseases following SARS-CoV-2 infection. To the best of our knowledge, this is the first systematic review and meta-analysis of comparative cohort studies estimating the risk of immune-mediated diseases following COVID-19 infection, using a control group without a history of infection and applying a rigorous criterion to exclude early outcomes, which allowed for the establishment of a solid quantitative basis for 13 diseases through pooled risk estimates (RR).

Two previous reviews had been published but they were based only on case reports. The first was published towards the end of the pandemic and was the initial study to compile data on this subject, finding that Guillain-Barré cases accounted for 48.5 % of reported new immune-mediated diseases cases, followed by autoimmune hemolytic anemia and immune thrombocytopenic purpura (9 % each), with a mean time between infection and symptoms of 9.8 days (range 2 to 33 days) [7]. The second review, published in early 2023, reported an average interval between SARS-CoV-2 infection and the diagnosis of immune-mediated disease of 23.7 days. The most frequently reported diseases were idiopathic inflammatory myopathies (39 %), SLE (25 %), and antisynthetase syndrome (14 %). Antinuclear antibodies (ANAs) were the most frequently reported autoantibodies [6]

Within the outcomes significantly associated with the infection after combining the results, there is a group of conditions that describe similar pathophysiological mechanisms between the disease and COVID-19, which may explain such associations.This group includes: Behçet's disease, IBD, spondyloarthritis, systemic sclerosis, SLE, polymyalgia rheumatica, psoriasis, RA, Sjögren's syndrome, and vasculitis. Firstly, the overactivation of innate immune cells induces excessive production of proinflammatory cytokines [19]; several damage-associated molecular patterns may also be expressed, further enhancing innate immune activation [19]. Additionally, SARS-CoV-2 increases the expression of angiotensin-II, favoring the establishment of a highly proinflammatory environment [20], and vascular damage, along with a higher expression of procoagulant molecules, has also been described [21]. Overactivated neutrophils may increase the production of extracellular traps, which may express potential autoantigens causing cross-reactivity and the synthesis of autoantibodies. Finally, molecular mimicry between viral epitopes and autoantigens can also cause cross-reactivity. All these mechanisms lead to an imbalance in the immune response, inducing loss of self-tolerance, which is the primary event responsible for immune-mediated diseases [19].

The case of Behçet's disease is interesting since its pathophysiology is characterized by neutrophil involvement and thrombosis, which are common to COVID-19; however, the predilection for venules and veins and the appropriate response of thrombosis to immunosuppressants in Behçet's disease differs from that of COVID-19, suggesting different underlying mechanisms [22]. In the case of IBD, beside the previously described mechanisms, it is well known that SARS-CoV-2 infection affects the small and large intestine by taking advantage of the increased expression of angiotensin-converting enzyme 2 receptors in enterocytes [23]. Consequently, the barrier function might be altered, triggering a proinflammatory response [24]. Potential mechanisms to explain the association with polymyalgia rheumatica, psoriasis, Sjögren's syndrome, SLE, and systemic sclerosis, and vasculitis are alike to those previously explained.

Regarding secondary spondyloarthritis due to SARS-CoV-2 infection, it has also been reported, although not as widely as other conditions [25]. Our findings, based on higher-quality evidence, confirm this association. It is worth noting that previous evidence assessed the development of spondylarthritis from the first day after infection. Additionally, it is important to consider that reactive arthritis has been one of the most common forms of spondyloarthritis described [26], and the studies included in our review did not use codes for this condition. Therefore, our results should not be generalized.

Concerning RA, studies that measured the outcome during the acute phase of the infection have also found an association in the same direction as ours [27,28]. Interestingly, some studies after the conclusion of our search have been published. For instance, the study by Marín and colleagues [28], which utilized 1 million hospital records in Colombia, found an increased risk of inflammatory arthritis (as per ICD-10 codes for RA) in patients with SARS-CoV-2 including outcomes within the first 30 days after infection. Bioinformatic studies have identified common peptides between SARS-CoV-2 and human proteins that could support molecular mimicry and increased auto-reactivity [28]. Additionally, reactive arthritis might be a possible explanation, with similar mechanisms [26].

The second group of outcomes evaluated includes T1DM and Guillain-Barré syndrome. The analyses of T1DM in the general population showed that there is a statistically significant association between infection and the new onset of the disease. However, when evaluating the outcome in the pediatric population, no evidence of such association was found. Other published systematic reviews support the association between diabetes and SARS-CoV-2 infection [29–31], however, it is important to note that the follow-up times in some studies included in those reviews considered events occurring during the first month after infection or did not differentiate between the type of diagnosed diabetes. We believe that adhering to the predefined criteria in our strategy will provide more specific information about the risk of an autoimmune mechanism. In the case of Guillain-Barré syndrome, although it is classically associated with prior infections through molecular mimicry mechanisms [32], we did not find a significant association in the primary analysis. This may be explained by the fact that neurological symptoms typically appear within the first few weeks after infection. A review of reported cases found that only 13 % of the cases occurred at least 30 days after the infection [33], which likely limited detection under our eligibility criteria. An interesting finding emerged in the sensitivity analysis, which included only studies with a longer follow-up period (≥90 days): in this case, the only outcome with available data was Guillain-Barré syndrome, and the association was positive and statistically significant. This suggests that studies with longer observation windows may be capturing truly delayed cases, possibly related to persistent immune-mediated mechanisms distinct from acute-phase processes.

Our study offers a comprehensive and detailed search that gathered information from more reliable studies than the case reports or case series on which previous syntheses were based. Additionally, we defined more specific eligibility criteria compared to those used in related research. As far as we know, this is the most updated report on the risk of immune-mediated disease after SARS-CoV-2 infection and is the first report focused on conditions that appeared after the acute phase of the infection.

We are also aware of some limitations. First, all the evidence was obtained from retrospective observational studies that used clinical records and existing databases, which may be incomplete, inaccurate, or inconsistent. Second, most of the immune-mediated diseases were identified using ICD-10 codes, which may not allow for precise patient identification and may have overlooked individuals with COVID-19. Third, the conclusions of the studies did not take into account post-exposure interventions, social practices, and healthcare protocols

during the pandemic, which could affect an accurate risk assessment. Fourth, although some of the included studies had large population-based samples, the overall number of eligible studies was limited. However, it is worth noting that this reduced number may be a consequence of the application of strict and highly specific eligibility criteria (e.g., non-infected comparators, exclusion of early-onset cases, and confirmed diagnostic verification). It is also important to highlight that most of the studies were conducted in high-income countries, which is common in the available scientific literature and may be explained by their access to high-quality health records and databases, as well as sufficient financial support for research development. It is worth noting that genetic backgrounds and environmental exposures are associated with the development of autoimmunity; for example, an increased risk of early-onset immune-mediated diseases was identified in minority ethnic groups in the UK [34]. Therefore, studies that include more diverse populations, especially from middle- and low-income countries, should be informative about the consistency of these results in other populations. Despite this, the combined samples were generally large enough to obtain a more precise and reliable effect. Fifth, most of the pooled outcomes in this meta-analysis originate from just two high-quality studies that already provide a broad perspective on the topic. However, their differences in design, population, and context enrich the synthesis; aggregating their data strengthens the robustness of the estimates, allows assessment of consistency across studies, and enhances the applicability of the findings to diverse settings. Despite finding studies with significant population samples, the number of studies focused on evaluating the risk of new-onset immune-mediated diseases after SARS-CoV-2 infection remains limited, which could complicate the interpretation of results in terms of the estimated effect. The heterogeneity observed among the studies for most outcomes indicates significant variability in the results, suggesting that the data may not be sufficiently consistent. Finally, following the massive, worldwide COVID-19 vaccination campaign that reduced the morbidity and mortality burden of the SARS-CoV-2 pandemic, concerns have arisen about the risk of new-onset immune-mediated diseases following COVID-19 vaccination. However, different studies based on robust data sets present contrasting results [35–39]. In addition, reports on vaccination-induced flare-ups of pre-existing immune-mediated diseases should remind physicians caring for this population of the possibility of these events [40]. As these events fell outside our scope, future research should investigate these challenges.

## Conclusions

This systematic review and meta-analysis provides the most up-to-date and comprehensive synthesis of the risk of new-onset immune-mediated diseases following SARS-CoV-2 infection. It focuses exclusively on conditions arising after the acute phase (≥30 days) and includes only comparative cohort studies with non-infected controls. By applying rigorous eligibility criteria and quantitative synthesis, we identified consistent associations with several immune-mediated diseases. Our findings strengthen the hypothesis that SARS-CoV-2 infection can trigger autoimmune responses in a subset of individuals and underscore the need for long-term clinical surveillance. Future research should build on this evidence by minimising protopathic bias, standardising diagnostic time windows, and incorporating under-represented populations, particularly from low- and middle-income countries. As autoimmunity is increasingly recognised as a feature of post-COVID-19 syndrome, an upsurge in incident immune-mediated diseases is anticipated. These findings should inform healthcare preparedness strategies and resource allocation to identify and support individuals at heightened risk.

## CRediT authorship contribution statement

**Ana M. Gil:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Julián Barahona-Correa:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jorge B. Flórez:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Daniel G. Fernández-Ávila:** Writing – review & editing, Validation, Supervision, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Zulma M. Cucunubá:** Writing – review & editing, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

## Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Zulma M Cucunuba reports financial support was provided by Ministerio de Ciencia, Tecnología e Innovación de Colombia, MinCiencias. The funder had no role in the study design, data collection, analysis, interpretation or writing of the repor. Authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability statement

All data and codes are available for the public through the open access Github repository. https://github.com/AGORA-COL/autoimmune-after-covid

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.semarthrit.2025.152805.

## Appendix A

Table A1., A2., A3.

**Table A1**
Search strategies and sources consulted.

| | |
|---|---|
| Databases | MEDLINE (Pubmed) |
| Search date | 27/06/2023 |
| Search date range | None |

(*continued on next page*)

**Table A1** (*continued*)

| | |
|---|---|
| Language restrictions | None |
| Other limits | None |
| Search strategy | ((("COVID-19″[Mesh] OR COVID[Title/Abstract] OR COVID-19[Title/Abstract] OR COVID19[Title/Abstract] OR "COVID 19″[Title/Abstract] OR coronavirus* [Title/Abstract] OR "coronavirus*"[Title/Abstract] OR 2019-nCoV[Title/Abstract] OR 19nCoV[Title/Abstract] OR 2019nCoV[Title/Abstract] OR nCoV[Title/Abstract] OR n-CoV[Title/Abstract] OR "SARS-CoV-2″[Mesh] OR SARS-CoV2[Title/Abstract] OR SARSCoV-2[Title/Abstract] OR SARSCoV2[Title/Abstract] OR 2019-novel CoV[Title/Abstract] OR Sars-coronavirus2[Title/Abstract] OR "novel CoV"[Title/Abstract]) AND ("after covid"[Title/Abstract] OR post-covid [Title/Abstract] OR postcovid[Title/Abstract] OR post-coronavir*[Title/Abstract] OR post-coronavir*[Title/Abstract] OR post-acute[Title/Abstract] OR postacute[Title/Abstract] OR "after acute"[Title/Abstract] OR "after discharge"[Title/Abstract] OR "after hospital discharge"[Title/Abstract] OR sequela* [Title/Abstract] OR post-infect*[Title/Abstract] OR post-viral[Title/Abstract] OR postviral[Title/Abstract] OR post-discharg*[Title/Abstract] OR postdischarge[Title/Abstract])) OR ("SARS-CoV-2 infection"[Title/Abstract] OR "Post-Acute COVID-19 Syndrome"[Mesh] OR "long COVID"[Title/Abstract] OR "long-COVID symptoms"[Title/Abstract] OR "long hauler"[Title/Abstract] OR post-COVID-19[Title/Abstract] OR "post-acute COVID-19 symptoms"[Title/Abstract] OR "COVID-19 sequelae"[Title/Abstract])) AND ((("Autoimmune Diseases"[Mesh] OR "Autoimmune Disease*"[Title/Abstract] OR "autoimmunologic disease*"[Title/Abstract] OR "autoimmune disorder*"[Title/Abstract] OR "autoimmunologic disorder*"[Title/Abstract] OR "immune-mediated inflammatory disease*"[Title/Abstract] OR "Arthritis, Rheumatoid"[Mesh] OR "Rheumatoid Vasculitis"[Mesh] OR "Lupus Erythematosus, Systemic"[Mesh] OR "Lupus Vasculitis, Central Nervous System"[Mesh] OR "Vasculitis"[Mesh] OR "Giant Cell Arteritis"[Mesh] OR "Polyarteritis Nodosa"[Mesh] OR "Takayasu Arteritis"[Mesh] OR "Behcet Syndrome"[Mesh] OR "Cogan Syndrome"[Mesh] OR "IgA Vasculitis"[Mesh] OR "Anti-Neutrophil Cytoplasmic Antibody-Associated Vasculitis"[Mesh] OR "Churg-Strauss Syndrome"[Mesh] OR "Granulomatosis with Polyangiitis"[Mesh] OR "Microscopic Polyangiitis"[Mesh] OR "Thromboangiitis Obliterans"[Mesh] OR "Vasculitis, Leukocytoclastic, Cutaneous"[Mesh] OR "Antiphospholipid Syndrome"[Mesh] OR "Sjogren's Syndrome"[Mesh] "Scleroderma, Systemic"[Mesh] OR "Spondylitis, Ankylosing"[Mesh] OR "Axial Spondyloarthritis"[Mesh] OR "Spondylarthritis"[Mesh] OR "Spondylarthropathies"[Mesh] OR "Myositis"[Mesh] OR "Polymyositis"[Mesh] OR "Antisynthetase syndrome" [Supplementary Concept] OR "Polymyalgia Rheumatica"[Mesh] OR "Hepatitis, Autoimmune"[Mesh] OR "Liver Cirrhosis, Biliary"[Mesh] OR "Cholangitis, Sclerosing"[Mesh] OR "Multiple Sclerosis"[Mesh] OR "Graves Disease"[Mesh] OR "Thyroiditis, Autoimmune"[Mesh] OR "Arthritis, Psoriatic"[Mesh] OR "Guillain-Barre Syndrome"[Mesh] OR "Still's Disease, Adult-Onset"[Mesh] OR "Arthritis, Juvenile"[Mesh] OR "Mucocutaneous Lymph Node Syndrome"[Mesh] OR "Glomerulonephritis, Membranous"[Mesh] OR "Vitiligo"[Mesh] OR "Alopecia Areata"[Mesh] OR "Inflammatory Bowel Diseases"[Mesh] OR "Colitis, Ulcerative"[Mesh] OR "Crohn Disease"[Mesh] OR "Autoimmune Pancreatitis"[Mesh] OR "Anti-Glomerular Basement Membrane Disease"[Mesh] OR "Anemia, Hemolytic, Autoimmune"[Mesh] OR "Autoimmune Diseases of the Nervous System"[Mesh] OR "Glomerulonephritis, IGA"[Mesh] OR "Immunoglobulin G4-Related Disease"[Mesh] OR "Latent Autoimmune Diabetes in Adults"[Mesh] OR "Linear IgA Bullous Dermatosis"[Mesh] OR "Pemphigoid, Bullous"[Mesh] OR "Pemphigus"[Mesh] OR "Undifferentiated Connective Tissue Diseases"[Mesh] OR "Rheumatoid arthritis" OR arthritis OR rheumarthritis OR "rheumatic arthritis" OR rheumatism OR "Systemic lupus erythematosus" OR Lupus OR Vasculitis OR "Giant cell arteritis" OR "Polyarteritis nodosa" OR "Takayasu's arteritis" OR Takayasu OR "IgA vasculitis" OR "ANCA-associated vasculitis" OR "allergic granulomatosis" OR Wegener OR "Buerger's disease" OR Buerger OR "Leukocytoclastic vasculitis" OR "Sjögren's syndrome" OR Sjoegren OR Sicca OR Scleroderma OR sclerosis OR Spondyloarthritis OR spondilitis OR Spondyloarthropathy OR spondyloarthropat* OR "Inflammatory myopathy" OR "Polymyalgia rheumatica" OR "Autoimmune hepatitis" OR "Primary biliary cholangitis" OR "Primary sclerosing cholangitis" OR "Multiple sclerosis" OR "Graves' disease" OR "Psoriatic arthritis" OR "Guillain-Barre syndrome" OR "Still's disease" OR "Juvenile arthritis" OR Kawasaki OR "Membranous glomerulopathy" OR Vitiligo OR "Alopecia areata" OR "Inflammatory bowel disease" OR "Autoimmune pancreatitis" OR "Membranous glomerulonephritis" OR "Autoimmune hemolytic anemia" OR "Autoimmune central nervous system disorders" OR "IgA nephropathy" OR "IgG4-related disease" OR "Type 1 diabetes" OR "Autoimmune blistering disease" OR "Undifferentiated connective tissue disease" OR "Behçet's disease" OR "Cogan's syndrome" OR Behcet* OR Cogan OR Kawasaki))) AND (((diagnos*[Title/Abstract] OR likelihood[Title/Abstract] OR likely[Title/Abstract]) AND (develop*[Title/Abstract] OR elevated[Title/Abstract] OR high*[Title/Abstract] OR heightened[Title/Abstract] OR increase*[Title/Abstract] OR increasing[Title/Abstract])) OR ("Incidence"[Mesh] OR "Risk"[Mesh] OR "Odds Ratio"[Mesh] OR Incidence OR probabilit* OR predict* OR risk OR risks OR "odds ratio" OR odds)) |
| Databases | Embase(Elsevier) |
| Search date | 27/06/2023 |
| Search date range | None |
| Language restrictions | None |
| Other limits | None |
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**Table A1** (*continued*)

| | |
|---|---|
| Databases | Web of science |
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| Search date range | None |
| Language restrictions | None |
| Other limits | None |
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| Databases | Cinahl |
| Search date | 27/06/2023 |
| Search date range | None |
| Language restrictions | None |
| Other limits | None |
| Search strategy | ((((MH COVID-19+) OR (TI COVID OR AB COVID) OR (TI COVID-19 OR AB COVID-19) OR (TI COVID19 OR AB COVID19) OR (TI "COVID 19″ OR AB "COVID 19″) OR (TI coronavirus* OR AB coronavirus*) OR (TI "corona virus*" OR AB "corona virus*") OR (TI 2019-nCoV OR AB 2019-nCoV) OR (TI 19nCoV OR AB 19nCoV) OR (TI 2019nCoV OR AB 2019nCoV) OR (TI nCoV OR AB nCoV) OR (TI n-CoV OR AB n-CoV) OR (MH SARS-CoV-2+) OR (TI SARS-CoV2 OR AB SARS-CoV2) OR (TI SARSCoV-2 OR AB SARSCoV-2) OR (TI SARSCoV2 OR AB SARSCoV2) OR (TI "2019-novel CoV" OR AB "2019-novel CoV") OR (TI Sars-coronavirus2 OR AB Sars-coronavirus2) OR (TI "novel CoV" OR AB "novel CoV")) AND ((TI "after covid" OR AB "after covid") OR (TI post-covid OR AB post-covid) OR (TI postcovid OR AB postcovid) OR (TI post-coronavir* OR AB post-coronavir*) OR (TI post-coronavir* OR AB post-coronavir*) OR (TI post-acute OR AB post-acute) OR (TI postacute OR AB postacute) OR (TI "after acute" OR AB "after acute") OR (TI "after discharge" OR AB "after discharge") OR (TI "after hospital discharge" OR AB "after hospital discharge") OR (TI sequela* OR AB sequela*) OR (TI post-infect* OR AB post-infect*) OR (TI post-viral OR AB post-viral) OR (TI postviral OR AB postviral) OR (TI post-discharg* OR AB post-discharg*) OR (TI postdischarge OR AB postdischarge))) OR ((TI "SARS-CoV-2 infection" OR AB "SARS-CoV-2 infection") OR (MH "Post-Acute COVID-19 Syndrome+") OR (TI "long COVID" OR AB "long COVID") OR (TI "long-COVID symptoms" OR AB "long-COVID symptoms") OR (TI "long hauler" OR AB "long hauler") OR (TI post-COVID-19 OR AB post-COVID-19) OR (TI "post-acute COVID-19 symptoms" OR AB "post-acute COVID-19 symptoms") OR (TI "COVID-19 sequelae" OR AB "COVID-19 sequelae"))) AND ((((MH "Autoimmune Diseases+") OR (TI "Autoimmune Disease*" OR AB "Autoimmune Disease*") OR (TI "autoimmunologic disease*" OR AB "autoimmunologic disease*") OR (TI "autoimmune disorder*" OR AB "autoimmune disorder*") OR (TI "autoimmunologic disorder*" OR AB "autoimmunologic disorder*") OR (TI "immune-mediated inflammatory disease*" OR AB "immune-mediated inflammatory disease*") OR (MH "Arthritis, Rheumatoid+") OR (MH "Rheumatoid Vasculitis+") OR (MH "Lupus Erythematosus, Systemic+") OR (MH "Lupus Vasculitis, Central Nervous System+") OR (MH Vasculitis+) OR (MH "Giant Cell Arteritis+") OR (MH "Polyarteritis Nodosa+") OR (MH "Takayasu Arteritis+") OR (MH "Behcet Syndrome+") OR (MH "Cogan Syndrome+") OR (MH "IgA Vasculitis+") OR (MH "Anti-Neutrophil Cytoplasmic Antibody-Associated Vasculitis+") OR (MH "Churg-Strauss Syndrome+") OR (MH "Granulomatosis with Polyangiitis+") OR (MH "Microscopic Polyangiitis+") OR (MH "Thromboangiitis Obliterans+") OR (MH "Vasculitis, Leukocytoclastic, Cutaneous+") OR (MH "Antiphospholipid Syndrome+") OR (MH "Sjogren's Syndrome+") OR (MH "Spondylitis, Ankylosing+") OR (MH "Axial Spondyloarthritis+") OR (MH Spondylarthritis+) OR (MH Spondylarthropathies+) OR (MH Myositis+) OR (MH Polymyositis+) OR (MW "Antisynthetase syndrome") OR (MH "Polymyalgia Rheumatica+") OR (MH "Hepatitis, Autoimmune+") OR (MH "Liver Cirrhosis, Biliary+") OR (MH "Cholangitis, Sclerosing+") OR (MH "Multiple Sclerosis+") OR (MH "Graves Disease+") OR (MH "Thyroiditis, Autoimmune+") OR (MH "Arthritis, Psoriatic+") OR (MH "Guillain-Barre Syndrome+") OR (MH "Still's Disease, Adult-Onset+") OR (MH "Arthritis, Juvenile+") OR (MH "Mucocutaneous Lymph Node Syndrome+") OR (MH "Glomerulonephritis, Membranous+") OR (MH Vitiligo+) OR (MH "Alopecia Areata+") OR (MH "Inflammatory Bowel Diseases+") OR (MH "Colitis, Ulcerative+") OR (MH "Crohn Disease+") OR (MH "Autoimmune Pancreatitis+") OR (MH "Anti-Glomerular Basement Membrane Disease+") OR (MH "Anemia, Hemolytic, Autoimmune+") OR (MH "Autoimmune Diseases of the Nervous System+") OR (MH "Glomerulonephritis, IGA+") OR (MH "Immunoglobulin G4-Related Disease+") OR (MH "Latent Autoimmune Diabetes in Adults+") OR (MH "Linear IgA Bullous Dermatosis+") OR (MH "Pemphigoid, Bullous+") OR (MH Pemphigus+) OR (MH "Undifferentiated Connective Tissue Diseases+") OR "Rheumatoid arthritis" OR arthritis OR rheumarthritis OR "rheumatic arthritis" OR rheumatism OR "Systemic lupus erythematosus" OR Lupus OR Vasculitis OR "Giant cell arteritis" OR "Polyarteritis nodosa" OR "Takayasu's arteritis" OR Takayasu OR "IgA vasculitis" OR "ANCA-associated vasculitis" OR "allergic granulomatosis" OR Wegener OR "Buerger's disease" OR Buerger OR "Leukocytoclastic vasculitis" OR "Sjögren's syndrome" OR Sjoegren OR Sicca OR Scleroderma OR sclerosis OR Spondyloarthritis OR spondilitis OR Spondyloarthropathy OR spondyloarthropat* OR "Inflammatory myopathy" OR "Polymyalgia rheumatica" OR "Autoimmune hepatitis" OR "Primary biliary cholangitis" OR "Multiple sclerosis" OR "Graves' disease" OR "Psoriatic arthritis" OR "Guillain-Barre syndrome" OR "Still's disease" OR "Juvenile arthritis" OR Kawasaki OR "Membranous glomerulopathy" OR Vitiligo OR "Alopecia areata" OR "Inflammatory bowel disease" OR "Autoimmune pancreatitis" OR "Membranous glomerulonephritis" OR "Autoimmune hemolytic anemia" OR "Autoimmune central nervous system disorders" OR "IgA nephropathy" OR "IgG4-related disease" OR "Type 1 diabetes" OR "Autoimmune blistering disease" |

(*continued on next page*)

**Table A1** (*continued*)

| | |
|---|---|
| | OR "Undifferentiated connective tissue disease" OR "Behçet's disease" OR "Cogan's syndrome" OR Behcet* OR Cogan OR Kawasaki))) AND ((((TI diagnos* OR AB diagnos*) OR (TI likelihood OR AB likelihood) OR (TI likely OR AB likely)) AND ((TI develop* OR AB develop*) OR (TI elevated OR AB elevated) OR (TI high* OR AB high*) OR (TI heightened OR AB heightened) OR (TI increase* OR AB increase*) OR (TI increasing OR AB increasing))) OR ((MH Incidence+) OR (MH Risk+) OR (MH "Odds Ratio+") OR Incidence OR probabilit* OR predict* OR risk OR risks OR "odds ratio" OR odds)) |

**Table A2**
Excluded studies.

| Tittle | Autor | Reason for exclusion |
|---|---|---|
| 6-Month Neurological and Psychiatric Outcomes In 236 379 Survivors of Covid-19: A Retrospective Cohort Study Using Electronic Health Records | Taquet, M.; Geddes, J.R.; Husain, M.; Luciano, S.; Harrison, P.J.; | Does not meet the definition of the outcome |
| Association Between Covid-19 Vaccination, Sars-Cov-2 Infection, And Risk of Immune Mediated Neurological Events: Population Based Cohort and Self-Controlled Case Series Analysis. | Li X; Raventós B; Roel E; Pistillo A; Martinez-Hernandez E; Delmestri A; Reyes C; Strauss V; Prieto-Alhambra D; Burn E; Duarte-Salles T; | Does not meet the definition of the outcome |
| Covid-19 and Thyroid Function: A Bi-Directional Two-Sample Mendelian Randomization Study | Li, G.H.Y.; Tang, C.M.; Cheung, C.L.; | Does not meet the definition of the exposure |
| Association Between Covid-19 Vaccination, Infection, And Risk of Guillain-Barre Syndrome, Bell's Palsy, Encephalomyelitis and Transverse Myelitis: A Population-Based Cohort And Self-Controlled Case Series Analysis | Xintong Li; Eugenia Martinez-Hernandez; Elena Roel Herranz; Antonella Delmestri; Talita Duarte-Salles; Victoria Strauss; Edward Burn; Daniel Prieto-Alhambra; | Preprint version of study already published and included |
| Risk for Newly Diagnosed Diabetes >30 Days After SARS-CoV-2 Infection Among Persons Aged <18 Years — United States, March 1, 2020–June 28, 2021 | Barrett CE, Koyama AK, Alvarez P, Chow W, Lundeen EA, Perrine CG, Pavkov ME, Rolka DB, Wiltz JL, Bull-Otterson L, Gray S, Boehmer TK, Gundlapalli AV, Siegel DA, Kompaniyets L, Goodman AB, Mahon BE, Tauxe RV, Remley K, Saydah S. | Does not meet the definition of the outcome |
| Covid-19 Infection Is a Risk Factor For Ckd And Glomerulonephritis | Roumelioti, M.E.; Mir, H.; Argyropoulos, C.; | Congress summary. Not available in full text. |
| Covid-19-Associated Guillain-Barré Syndrome in The First Wave of Covid-19 Pandemic in Lombardia: Increased Incidence or Increased Seroprevalence? | Boneschi, F.M.; Colombo, A.; Bresolin, N.; Sessa, M.; Pozzato, M.; Grampa, G.; Bassi, P.; Magni, E.; Versino, M.; Ferrarese, C.; Zarcone, D.; Albanese, A.; Micieli, G.; Zanferrari, C.; Cagnana, A.; Ferrante, C.; Zilioli, A.; Locatelli, D.; Calloni, M.; Delodovici, M.L.; Foresti, C.; Frigeni, B.; Canella, S.; Xhani, R.; Crabbio, M.; Clemenzi, A.; Mauri, M.; Beretta, S.; La Spina, I.; Bernasconi, S.; Cavallini, A.; Ranieri, M.; D'Adda, E.; Fruguglietti, M.E.; Peverelli, L.; Agosti, E.; Rigamonti, A.; Salmaggi, A.; | Does not meet the definition of the outcome |
| Does Covid-19 Predisposes Patients to Type 1 Diabetes Mellitus? | Ata A; Jalilova A; Kırkgöz T; Işıklar H; Demir G; Altınok YA; Özkan B; Zeytinlioğlu A; Darcan Ş; Özen S; Gökşen D; | Does not meet the definition of the outcome |
| Increased Incidence of Adult-Onset Still's Disease in Association with Covid-19 Vaccination and Sars-Cov-2 Infection. | Gottschalk MN; Heiland M; Nahles S; Preissner R; Petri WA; Wendy S; Preissner S; | Does not meet the definition of the outcome |
| Increased Incidence of Childhood Type 1 Diabetes During Covid-19 Pandemic. Figures From an Italian Tertiary Care Center | Deodati, A.; Rapini, N.; Pampanini, V.; Ciampalini, P.; Matteoli, M.C.; Patera, I.P.; Schiaffini, R.; Cianfarani, S.; | Congress summary. Not available in full text. |
| Increased Prevalence of Autoimmune Thyroid Disease After Covid-19: A Single-Center, Prospective Study. | Rossini A; Cassibba S; Perticone F; Benatti SV; Venturelli S; Carioli G; Ghirardi A; Rizzi M; Barbui T; Trevisan R; Ippolito S; | Does not meet the definition of the outcome |
| Neurographic Evidence of Inflammatory Polyneuropathies in Peri-Covid-19 Circumstances and Their Relationship with Acute Disease Severity and Inflammatory Storm. | Hasrat NH; Kadhum HJ; Hashim AR; Yakob ZA; Kadhim LA; Farid HA; | Does not meet the definition of the exposure |
| New Insights into Guillain-Barré Syndrome and Covid-19 Relationship: An Observational Multicenter Study | Cotti Piccinelli, S.; Gazzina, S.; Foresti, C.; Frigeni, B.; Servalli, M.C.; Sessa, M.; Cosentino, G.; Marchioni, E.; Ravaglia, S.; Briani, C.; Castellani, F.; Zara, G.; Brianchi, F.; Del Carro, U.; Fazio, R.; Filippi, M.; Magni, E.; Natalini, G.; Palmerini, F.; Perotti, A.M.; Bellomo, A.; Osio, M.; Nascimbene, C.; Carpo, M.; Rasera, A.; Squintani, G.; Doneddu, P.E.; Bertasi, V.; Cotelli, M.S.; Bertolasi, L.; Fabrizi, G.M.; Ferrari, S.; Ranieri, F.; Caprioli, F.; Grappa, E.; Manganotti, P.; Broglio, L.; De Maria, G.; Poli, L.; Leggio, U.; Rasulo, F.; Latronico, N.; Nobile-Orazio, E.; Beghi, E.; Padovani, A.; Uncini, A.; Filosto, M.; | Does not meet the definition of the outcome |
| New Onset Autoimmune Disease More Common After Covid-19 | Hileman, C.O.; Patil, N.T.; McComsey, G.A.; | Congress summary. Not available in full text. |
| No Effects of Covid-19 On the Development of Type 1 Diabetes Autoimmunity and No Evidence of An Increased Frequency of Sars-Cov-2 Antibodies in Newly Diagnosed Type 1 Diabetes Patients Relative to Healthy Subjects. | Claudio T; Raffaella N; Valeria T; Tiziana F; Laura P; Francesca S; Valeria F; Monica M; Enrica M; Andrea L; Fabio M; Francesco C; Susanna M; | Does not meet the definition of the outcome |
| Risk Of Autoimmune Diseases in Patients with Covid-19 | Wei, J.; Chen, T.; Wang, S.; Chang, R.; Chen, H.; Hung, Y.; | Congress summary. Not available in full text. |
| Sars-Cov-2 Infection and Subsequent Risk of Type 1 Diabetes In 1.2 million Children | Gulseth, H.L.; Ruiz, P.L.D.; Størdal, K.; Karlstad, Ø.; Gunnes, N.; Lund-Blix, N.A.; Bøås, H.; Stene, L.C.; Tapia, G.; | Congress summary. Not available in full text. |
| Sars-Cov-2 Infections and Presymptomatic Type 1 Diabetes Autoimmunity in Children and Adolescents from Colorado, USA, And Bavaria, Germany. | Rewers M; Bonifacio E; Ewald D; Geno Rasmussen C; Jia X; Pyle L; Ziegler AG; | Does not meet the definition of the outcome |
| The Impact of The Covid-19 Pandemic on Primary Care Referrals and New Diagnoses of Inflammatory Arthritis | Bajpai, R.; Burton, C.; Mason, K.J.; Bailey, J.; Jordan, K.P.; Mallen, C.D.; Welsh, V.; | Congress summary. Not available in full text. |
| The Incidence of Myasthenia Gravis in The Republic of Moldova Before and During the Covid-19 Pandemic | Bubuioc, A.M.; Alboini, P.E.; Leone, M.; Lisnic, V.; | Congress summary. Not available in full text. |
| Association Of Covid-19 Infection with Incident Diabetes. | Naveed, Zaeema; Velásquez García, Héctor A.; Wong, Stanley; Wilton, James; McKee, Geoffrey; Mahmood, Bushra; Binka, Mawuena; Rasali, Drona; Janjua, Naveed Z.; | Does not meet the definition of the outcome |

(*continued on next page*)

**Table A2** (*continued*)

| | | |
|---|---|---|
| Incident Autoimmune Diseases in Association with A Sars-Cov-2 Infection: A Matched Cohort Study | Tesch F; Ehm F; Vivirito A; Wende D; Batram M; Loser F; Menzer S; Jacob J; Roessler M; Seifert M; Kind B; König C; Schulte C; Buschmann T; Hertle D; Ballesteros P; Baßler S; Bertele B; Bitterer T; Riederer C; Sobik F; Reitzle L; Scheidt-Nave C; Schmitt J; | Preprint version of study already published and included |
| The Incidence of Immune Mediated Inflammatory Diseases Following Covid-19: A Matched Cohort Study in Uk Primary Care | Umer Syed; Anuradhaa Subramanian; David C Wraith; Janet M Lord; Kirsty McGee; Krishna Ghokale; Krishnarajah Nirantharakumar; Shamil Haroon; | Does not meet the definition of the outcome |
| Risk Of Adverse Events After Covid-19 In Danish Children and Adolescents and Effectiveness of Bnt162b2 in Adolescents: Cohort Study. | Kildegaard H; Lund LC; Højlund M; Stensballe LG; Pottegård A; | Does not meet the definition of the outcome |
| Late Conditions Diagnosed 1–4 Months Following An | Jennifer R. Chevinsky,2 Guoyu Tao, Amy M. Lavery, Esther A. Kukielka, Eleanor S. Click, Donald Malec, Lyudmyla Kompaniyets, Beau B. Bruce, Hussain Yusuf, Alyson B. Goodman, Meredith G. Dixon, Jolene H. Nakao, S. Deblina Datta, William R. MacKenzie, Sameer S. Kadri, Sharon Saydah,1 Jennifer E. Giovanni, and Adi V. Gundlapalli | Does not present any data on the outcome of interest |
| Association Of SARS-Cov-2 Infection with New-Onset Type 1 Diabetes Among Pediatric Patients From 2020 To 2021 | Ellen K. Kendall, BA; Veronica R. Olaker, BS; David C. Kaelber, MD, PhD; Rong Xu, PhD; Pamela B. Davis, MD, PhD | Does not meet the definition of the outcome. |

**Table A3**
Risk-of-bias in non-randomized studies of exposure (ROBINS-E).

| **Domains of bias** | Chang R, 2023 [11] | Kompaniyets L, 2022 [12] | McKeigue PM, 2023 [15] | Noorzae R, 2023[16] | Mizrahi B, 2022 [14] | Tesch F, 2023 [17] | Xu E, 2022 [13] | Zareini B, 2023 [18] |
|---|---|---|---|---|---|---|---|---|
| Risk of bias due to confounding | Low risk of bias | High risk of bias | High risk of bias | High risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias |
| Risk of bias arising from measurement of the exposure | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias |
| Risk of bias in selection of participants into the study (or into the analysis) | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias |
| Risk of bias due to post-exposure interventions | Some concerns | Some concerns | Some concerns | Some concerns | Low risk of bias | Some concerns | Some concerns | Some concerns |
| Risk of bias due to missing data | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias |
| Risk of bias arising from measurement of the outcome | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias | Low risk of bias |
| Risk of bias in selection of the reported result | Some concerns | Some concerns | Some concerns | Some concerns | Some concerns | Some concerns | Some concerns | Some concerns |
| Risk of bias | Some concerns | Some concerns | Some concerns | Some concerns | Some concerns | Some concerns | Some concerns | Some concerns |

## References


[1] Kocivnik N, Velnar T. A review pertaining to SARS-CoV-2 and autoimmune diseases: what is the connection? Life 2022;12. https://doi.org/10.3390/life12111918.

[2] Pisetsky DS. Pathogenesis of autoimmune disease. Nat Rev Nephrol 2023;19:509–24.

[3] Thaweethai T, Jolley SE, Karlson EW, Levitan EB, Levy B, McComsey GA, et al. Development of a definition of postacute sequelae of SARS-CoV-2 infection. JAMA 2023;329:1934–46.

[4] Li J, Zhou Y, Ma J, Zhang Q, Shao J, Liang S, et al. The long-term health outcomes, pathophysiological mechanisms and multidisciplinary management of long COVID. Signal Transduct Target Ther 2023;8:416.

[5] Faillie JL. Indication bias or protopathic bias? Br J Clin Pharmacol 2015:779–80.

[6] Kouranloo K, Dey M, Elwell H, Nune A. A systematic review of the incidence, management and prognosis of new-onset autoimmune connective tissue diseases after COVID-19. Rheumatol Int 2023:43. https://doi.org/10.1007/s00296-023-05283-9.

[7] Saad MA, Alfishawy M, Nassar M, Mohamed M, Esene IN, Elbendary A. COVID-19 and Autoimmune Diseases: a systematic review of reported cases. Curr Rheumatol Rev 2021;17. https://doi.org/10.2174/1573397116666201029155856.

[8] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372. https://doi.org/10.1136/bmj.n71.

[9] Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. Syst Rev 2016;5:210.

[10] Higgins JPT, Morgan RL, Rooney AA, Taylor KW, Thayer KA, Silva RA, et al. A tool to assess risk of bias in non-randomized follow-up studies of exposure effects (ROBINS-E). Env Int 2024:04.

[11] Chang R, Yen-Ting Chen T, Wang SI, Hung YM, Chen HY, Wei CCJ. Risk of autoimmune diseases in patients with COVID-19: a retrospective cohort study. EClinicalMedicine 2023;56:101783.

[12] Kompaniyets L, Bull-Otterson L, Boehmer TK, Baca S, Alvarez P, Hong K, et al. Post-COVID-19 symptoms and conditions among children and adolescents - United States, March 1, 2020-January 31, 2022. MMWR Morb Mortal Wkly Rep 2022;71:993–9.

[13] Xu E, Xie Y, Al-Aly Z. Long-term neurologic outcomes of COVID-19. Nat Med 2022;28:2406–15.

[14] Mizrahi B, Sudry T, Flaks-Manov N, Yehezkelli Y, Kalkstein N, Akiva P, et al. Long covid outcomes at one year after mild SARS-CoV-2 infection: nationwide cohort study. BMJ 2023;380:e072529.

[15] McKeigue PM, McGurnaghan S, Blackbourn L, Bath LE, McAllister DA, Caparrotta TM, et al. Relation of incident type 1 diabetes to recent COVID-19 infection: cohort study using e-health record linkage in Scotland. Diabetes care 2023:921–8.

[16] Noorzae R, Junker TG, Hviid AP, Wohlfahrt J, Olsen SF. Risk of type 1 diabetes in children is not increased after SARS-CoV-2 infection: a nationwide prospective study in Denmark. Diabetes Care 2023;46:1261–4.

[17] Tesch F, Ehm F, Vivirito A, Wende D, Batram M, Loser F, et al. Incident autoimmune diseases in association with SARS-CoV-2 infection: a matched cohort study. Clin Rheumatol 2023;42:2905–14.

[18] Zareini B, Sørensen KK, Eiken PA, Fischer TK, Kristensen PL, Lendorf ME, et al. Association of COVID-19 and Development of type 1 diabetes: a Danish nationwide register study. Diabetes Care 2023;46:1477–82.

[19] Liu Y, Sawalha AH, Lu Q. COVID-19 and autoimmune diseases. Curr Opin Rheumatol 2021;33:155–62.

[20] Tripathy A, Swain N, Gupta B. The COVID-19 pandemic: an increased risk of rheumatoid arthritis. Future Virol 2021. https://doi.org/10.2217/fvl-2020-0393 [cited 12 Dec 2023].

[21] Mv P, Auanassova A, Yessirkepov M, Zimba O, Gasparyan AY, Kitas GD, et al. New-onset systemic vasculitis following SARS-CoV-2 infection and vaccination: the trigger, phenotype, and outcome. Clin Rheumatol 2023;42:2761–75.

[22] Yazici Y, Hatemi G, Bodaghi B, Cheon JH, Suzuki N, Ambrose N, et al. Behçet syndrome. Nat Rev Dis Primers 2021;7:1–14.

[23] Dvornikova KA, Bystrova EY, Churilov LP, Lerner A. Pathogenesis of the inflammatory bowel disease in context of SARS-COV-2 infection. Mol Biol Rep 2021;48. https://doi.org/10.1007/s11033-021-06565-w.

[24] Yang C, SY Xiao. COVID-19 and inflammatory bowel disease: a pathophysiological assessment. Biomed Pharmacother 2021;135. https://doi.org/10.1016/j.biopha.2021.111233.
[25] Gracia-Ramos AE, Martin-Nares E, Hernández-Molina G. New onset of autoimmune diseases following COVID-19 diagnosis. Cells 2021;10. https://doi.org/10.3390/cells10123592.
[26] Migliorini F, Karlsson J, Maffulli N. Reactive arthritis following COVID-19: cause for concern. Knee Surg Sports Traumatol Arthrosc 2023;31:2068–70.
[27] Peng K, Li X, Yang D, Chan SCW, Zhou J, Wan EYF, et al. Risk of autoimmune diseases following COVID-19 and the potential protective effect from vaccination: a population-based cohort study. EClinicalMedicine 2023;63:102154.
[28] Marín JS, Mazenett-Granados EA, Salazar-Uribe JC, Sarmiento M, Suárez JF, Rojas M, et al. Increased incidence of rheumatoid arthritis after COVID-19. Autoimmun Rev 2023;22. https://doi.org/10.1016/j.autrev.2023.103409.
[29] Banerjee M, Pal R, Dutta S. Risk of incident diabetes post-COVID-19: a systematic review and meta-analysis. Prim Care Diabetes 2022;16:591–3.
[30] Ssentongo P, Zhang Y, Witmer L, Chinchilli VM, Ba DM. Association of COVID-19 with diabetes: a systematic review and meta-analysis. Sci Rep 2022;12:20191.
[31] Rahmati M, Yon DK, Lee SW, Udeh R, McEVoy M, Kim MS, et al. New-onset type 1 diabetes in children and adolescents as postacute sequelae of SARS-CoV-2 infection: a systematic review and meta-analysis of cohort studies. J Med Virol 2023;95:e28833.
[32] Willison HJ, Jacobs BC, van Doorn PA. Guillain-Barré syndrome. Lancet 2016;388:717–27.
[33] Rojas GM, García JPZ, Becerra-Hernández LV. Guillain-Barré syndrome post-SARS-CoV-2 infection and post-vaccination against COVID-19: a systematic review of cases. Acta Neurol Colomb 2022;38:154–71.
[34] Sharma-Oates A, Zemedikun DT, Kumar K, Reynolds JA, Jain A, Raza K, et al. Early onset of immune-mediated diseases in minority ethnic groups in the UK. BMC Med 2022;20:1–12.
[35] Shan J, Hu X, Chen T, Wang Y, Huang B, Xin Y, Xu H. COVID-19 vaccination and the risk of autoimmune diseases: a mendelian randomization study. Front Public Health 2024;12:1322140.
[36] Jung SW, Jeon JJ, Kim YH, Choe SJ, Lee S. Long-term risk of autoimmune diseases after mRNA-based SARS-CoV2 vaccination in a Korean, nationwide, population-based cohort study. Nat Commun 2024;15:6181.
[37] Pan H, Yu Y, Li X, Wang M, Wen C, Dai Q, Huang L. Vaccination and rheumatoid arthritis: an updated systematic review and meta-analysis of data from 25,949,597 participants. BMC Public Health 2025;25:933.
[38] Chen CC, Chen CJ. New-onset inflammatory arthritis after COVID-19 vaccination: a systematic review. Int J Rheum Dis 2023;26:267–77.
[39] Fraenza F, Cagnotta C, Gaio M, Sportiello L, Scavone C, Capuano A, Trama U. Disproportionality analysis of European safety reports on autoimmune and rheumatic diseases following COVID-19 vaccination. Sci Rep 2025;15(1):14740.
[40] Valero C, Baldivieso-Achá JP, Uriarte M, Vicente-Rabaneda EF, Castañeda S, García-Vicuña R. Vasculitis flare after COVID-19: report of two cases in patients with preexistent controlled IgA vasculitis and review of the literature. Rheumatol Int 2022;42:1643–52.