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REVIEW ARTICLE

Feasibility and Effectiveness of Vaccines for COVID-19: An Umbrella Review

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Abstract: **Introduction:** In January 2020, WHO declared the 2019 Coronavirus Disease (COVID-19) a pandemic. Though COVID-19 vaccines are recommended, ongoing surveillance is crucial due to potential unforeseen events. Evaluation of long-term effectiveness and safety and addressing emerging variants are vital. This study integrates systematic reviews to assess COVID-19 vaccine efficacy, immunogenicity, and safety comprehensively. **Methods:** This study was an umbrella review study on the feasibility and effectiveness of vaccines for COVID-19. We conducted a comprehensive search in PubMed, Web of Science, Embase and Scopus, using MeSH terms and keywords related to COVID-19 vaccines. Inclusion criteria comprised peer-reviewed systematic reviews and meta-analyses in English, focusing on feasibility and effectiveness. Exclusion criteria targeted non-systematic reviews exclusively on vaccine safety and duplicates. Two independent reviewers screened and resolved discrepancies. Data extraction included key details. Methodological quality was assessed using the ROBIS tool. Data synthesis involves narrative and, if applicable, quantitative synthesis (meta-analysis). Reporting followed PRISMA guidelines. **Results:** A total of 32 systematic reviews were included in the study, of which 20 also conducted a meta-analysis. The studies investigated in the included reviews ranged from 7 to 74. The included articles were conducted in various countries around the globe. The findings indicated that COVID-19 vaccines are generally safe and effective for individuals with various medical conditions. The overall risk of bias for the included studies was assessed as low risk. **Conclusions:** The study outcomes indicated that mRNA vaccines exhibit a higher incidence of adverse events but demonstrate greater efficacy. Conversely, inactivated and protein subunit vaccines are safer but exhibit lower efficiency. Moreover, the vaccine is considered safe for individuals with specific conditions such as inflammatory bowel disease, solid organ transplant recipients, children, pregnant individuals, and those with hematologic problems. Ultimately, the acceptance of the COVID-19 vaccine among individuals is influenced by various factors, including geographic, socioeconomic, and pandemic-related considerations.

Keywords: COVID-19, SARS-CoV-2, Vaccines, Feasibility, Effectiveness

Key findings:

- SARS-CoV-2 vaccines are generally safe and effective for individuals with various conditions, including those with Inflammatory Bowel Disease (IBD) and solid organ transplant recipients who may benefit from a third vaccine dose.
- Inactivated COVID-19 vaccines like Sinovac, Sinopharm, Bharat Biotech, and protein subunit vaccines such as Novavax are considered safe with fewer adverse events.
- mRNA vaccines have demonstrated high effectiveness in preventing SARS-CoV-2 infection, although their efficacy may be slightly reduced in individuals with obesity.

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1. Introduction

In January 2020, the World Health Organization (WHO) designated COVID-19, a pandemic that emerged from the SARS-CoV-2 virus (1).

Globally, an extensive vaccination effort commenced in early 2021, utilizing mRNA and vector-based vaccines. By November 2022, more than 4.97 billion individuals had been fully vaccinated, contributing to pandemic mitigation (2). SARS-CoV-2 vaccines have effectively triggered neutralizing humoral and cellular immunity, substantially decreasing infections, hospitalizations, and deaths during clinical trials (3). The eagerly anticipated recommended vaccinations hold the promise of bringing an end to the pandemic (4).

The persistent rise in COVID-19 cases, fatalities, and enduring medical, social, and economic impacts underscores the urgency for swift preventive measures (5). Vaccination, with uniquely designed vaccines, not only halts the spread of the virus but also mitigates the severe health consequences of the pandemic (6).

It's important to note that the rapid development and deployment of the COVID-19 vaccine, being the most recent globally, may lead to unforeseen events alongside immunity protection (7). Despite ongoing assessments of benefits and drawbacks, COVID-19 vaccines are recommended (8). Moreover, the widespread administration of these vaccines requires ongoing, thorough surveillance and research to assess their efficacy, safety, and potential side effects.

Evaluating the long-term effectiveness, potency, and safety of COVID-19 vaccines is crucial, considering three key factors. Firstly, the emergence of new SARS-CoV-2 variants with modified infection capacity and immune neutralization properties. Secondly, understanding the vaccine's side effects across diverse socio-demographic settings. Lastly, assessing the longevity of antibodies produced against the virus is vital for comprehensive analyses (9, 10).

Diverse COVID-19 vaccines, such as mRNA vaccines, adenovirus vector vaccines, inactivated virus vaccines, and protein subunit vaccines, have shown a substantial decrease in the occurrence of severe or critical diseases (11). Maintaining vigilance is crucial for detecting potentially serious adverse events and assessing efficacy against emerging variants of concern through molecular surveillance to prevent a new pandemic. Highlighting the safety of available vaccines remains crucial, as it significantly influences vaccine acceptance among recipients (12, 13). Several systematic reviews have explored the significance of this issue.

In this umbrella review, we evaluate COVID-19 vaccine feasibility and effectiveness across diverse populations and regions, considering various vaccine types, doses, and schedules. The authors analyze systematic reviews and meta-analyses of randomized trials, observational studies, and real-world data to assess vaccine uptake, safety, and impact on disease transmission and severity. Our goal is to offer insights into optimal vaccination strategies globally.

2. Methods

2.1. Search Strategy and Selection Criteria

This study was an umbrella review of the feasibility and effectiveness of vaccines for COVID-19. We conducted a comprehensive literature search to identify systematic reviews and meta-analyses related to the feasibility and effectiveness of COVID-19 vaccines. Electronic databases, including PubMed, Web of Science, Embase, and Scopus, were searched from 2020/09/01 until 2024/08/25. The search strategy (Table 1) utilized a combination of Medical Subject Headings (MeSH) terms and keywords related to COVID-19 vaccines.

2.2. Inclusion and Exclusion Criteria

Studies were included if they met the following criteria:

Systematic reviews and meta-analyses focusing on the feasibility and effectiveness of COVID-19 vaccines, published in peer-reviewed journals, and available in English.

Studies were excluded if:

They were not systematic reviews or meta-analyses, focused exclusively on vaccine safety without addressing feasibility and effectiveness, and were duplicate publications.

2.3. Data Extraction

Two independent reviewers screened titles and abstracts to identify potentially relevant systematic reviews and meta-analyses. Full-text articles were then assessed for eligibility based on inclusion and exclusion criteria. Discrepancies were resolved through discussion and consensus.

Data were extracted from eligible studies using a standardized form. Key information included The first author, year (reference), country, type of review, Sources searched/Search period, number of studies included, population, sex (M/F), age (mean), purpose, type of vaccine, intervention, and outcome.

2.4. Quality Assessment

The authors in this review article explicitly addressed the research question and verified a cross-checking of the regarded articles to ensure high-quality standards and restraint overlapping content. This article considers limitations or potential biases and reports on their quality and relevance. The authors reported these shortcomings and did not decrease the overall relevance and validity of the paper.

The risk of bias for the included systematic reviews was assessed using the ROBIS tool (Table 2), a new tool developed to evaluate the level of bias in systematic reviews. The assessment process involves three phases: determining relevance,

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identifying issues with the review process, and assessing bias risk. The second phase examines four domains where bias could potentially be introduced: criteria for study eligibility, the identification and selection of studies, data collection and appraisal of the study, and synthesis of results. The third phase determines the overall risk of bias in the review based on the outcomes from phases 1 and 2 (14). Two authors independently evaluated the risk of bias in the included reviews. In cases of disagreement, a third author was consulted to reach a consensus.

Studies were evaluated based on criteria such as the clarity of research questions, appropriateness of search strategies, and rigor of data synthesis. Two reviewers conducted quality assessments independently, with any discrepancies resolved through discussion.

2.5. Data Synthesis

A narrative synthesis and, if applicable, a quantitative synthesis (meta-analysis) of the findings from the included systematic reviews and meta-analyses were conducted. Feasibility and effectiveness outcomes were summarized, and the overall strength of evidence was evaluated. The reporting of this umbrella review adheres to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

3. Results

This umbrella review examined the feasibility and effectiveness of various COVID-19 vaccines, comparing outcomes across different vaccine types based on data from 32 systematic reviews and meta-analyses.

3.1. Literature search

A total of 1139 studies were identified via systematic search. After the removal of the duplicate studies (n=29), the remaining 1110 studies were screened, and 721 studies were removed following title, abstract, and full-text screening. The remaining 389 studies were sought for retrieval and 94 studies were removed since they could not be retrieved. After the assessment of the remaining 295 studies for eligibility, 263 studies were excluded for the following reasons: lacking experimental data (n=257), and other study types (n=6). Finally, 32 articles met the eligibility criteria and were included in the current study (Figure 1).

3.2. Characteristics of the included studies

Of the 32 included systematic reviews, 20 articles also included a quantitative analysis or meta-analysis. The number of studies investigated in the included articles ranged from 7 to 74. The included studies were done in various countries including the United States, Poland, the United Kingdom, Italy, Singapore, Japan, China, Georgia, Indonesia, Bangladesh, Saudi Arabia, The Republic of Korea, Taiwan, Chile, Israel, Egypt, Australia, Thailand, Qatar, and Iran (Table 3).

3.3. Outcomes

The most frequently investigated vaccine types were mRNA vaccines (BNT162b2 by Pfizer/BioNTech and mRNA-1273 by Moderna), viral vector vaccines (Ad26.COVID-2.S by Johnson Johnson's Janssen and ChAdOx1 nCoV-19 by Oxford/AstraZeneca), and inactivated virus vaccines (CoronaVac by Sinovac and BBIBP-CorV by Sinopharm). The included populations can be categorized into several broad groups: special medical conditions such as patients with IBD (15), hematological malignancies (16), solid tumor cancers (17), lupus nephritis or SLE (18), rheumatic diseases (19), immune-mediated dermatological diseases (20), autoimmune neurological disorders (21), and CKD (22); solid organ transplant recipients (23) and allogeneic hemopoietic stem cell recipients (24); age-specific groups such as pediatric and adolescent populations (25, 26), and adults greater than 60 years of age (27); pregnant women(28-31); immunocompromised patients including those receiving renal replacement therapy (32) and other immunocompromised conditions (33); and people who were overweight or obese (34) (Table 3).

The results of studies on various populations regarding COVID-19 vaccination outcomes reveal several key insights. Overall, COVID-19 vaccines including mRNA, protein subunit, and viral vector vaccines, demonstrate good efficacy, safety, and immune response in adults aged 18 and above (35). Sinovac, Sinopharm, Bharat Biotech, and Novavax vaccines are considered safe due to their milder side effects (36). Both adenovirus vector vaccines and mRNA vaccines show high efficacy in producing neutralizing antibodies (8). For specific populations, SARS-CoV-2 vaccines are safe and effective for patients with IBD (15). Solid organ transplant recipients benefit from a third dose of mRNA vaccines, although some remain seronegative (23). Patients with hematological malignancies exhibit lower seroconversion rates, influenced by the type of malignancy and treatment, yet the vaccines are safe (16). Patients with rheumatologic diseases experience effective prevention of severe illness, with improved immune responses after the second dose (19). Patients with CKD on dialysis show an effective immune response with few adverse events (22). Individuals with autoimmune neurological disorders tolerate vaccines well with few adverse events (21). Solid tumor cancer patients have a safety profile comparable to the general population (17), while those with immune-mediated dermatological diseases have reduced vaccine response but effective protection (20). Pregnant women experience reduced odds of infection and improved pregnancy outcomes, with side effects similar to non-pregnant women (28, 31). Allogeneic hemopoietic stem cell recipients have a 74% humoral response rate following three doses, suggesting the potential for additional booster doses (24). For age-specific populations, children and adolescents find vaccines safe and effective, with occasional mild to moderate adverse effects (25). Adults over 60 benefit from vaccination through reduced breakthrough infections, hos-

pitalizations, and deaths, with effectiveness increasing with additional doses (27).

Regarding general effectiveness, two mRNA doses prevent SARS-CoV-2 infection most effectively, with the Pfizer vaccine showing 91% effectiveness and an overall immune response of 95% after vaccination (26). Vaccines effectively reduce hospitalization and death. However, while vaccines have high efficacy against Alpha and Gamma variants, they show moderate efficacy against Beta and Delta variants, raising concerns about booster effectiveness against Omicron (37). Vaccine acceptance varies by geography and demographics. Factors such as geography and pandemic conditions influence vaccine acceptance in different countries (18, 29, 30, 38). Low vaccine engagement in Algeria contributes to slow vaccination rates (39), while tailored interventions are needed in Italy to counteract vaccine hesitancy (38). Adverse events are generally mild to moderate, including injection site pain, fever, fatigue, and musculoskeletal symptoms, with severe adverse effects being rare. Pregnant women show no significant safety concerns. Adolescents need monitoring for adverse events, especially differences in sex and vaccine doses. For immunocompromised patients, Evusheld is effective for COVID-19 prevention and treatment. Continued evaluation and larger studies are needed to confirm high doses' benefits and adverse events (Table 3).

3.4. Quality and Risk of Bias Assessment

The included studies were evaluated via the ROBIS tool. Using this tool, the overall risk of bias for the studies was evaluated as low risk, and the studies were considered high quality. Among the ROBIS tool domains, domain 2, regarding the identification and selection of studies, was the single domain in which 18 (56.25%) studies struggled to address the concerns adequately (Table 2).

4. Discussion

This umbrella review aimed to comprehensively evaluate the feasibility and effectiveness of vaccines developed for COVID-19. The findings of this review indicated that SARS-CoV-2 vaccines demonstrate a favorable safety and efficacy profile for individuals with diverse health conditions, encompassing those diagnosed with Inflammatory Bowel Disease (IBD) and recipients of solid organ transplants. Previous research indicates that COVID-19 vaccines, particularly mRNA vaccines like Pfizer-BioNTech and Moderna, are generally safe and well-tolerated in patients with IBD. The occurrence and characteristics of adverse events post-vaccination align with those observed in the general population (40, 41). In a retrospective cohort study conducted by Ben-Tov and colleagues, the effectiveness of BNT162b2 was assessed in a large Israeli population consisting of 12,231 vaccinated patients with IBD and 36,254 matched patients without IBD. Their findings indicated that there were notably low rates of breakthrough infections in both groups between 7 and 14 days after the completion of the vaccine series (42). In 2022, Kappelman and colleagues conducted a prospective cohort study involving 1,909 patients with IBD who were vaccinated with BNT162b2, mRNA-1273, and Ad26.COV2.S. The study revealed that individuals with IBD exhibited the capacity to generate a humoral immune response after receiving the COVID-19 vaccine (43). Individuals with weakened immune systems, such as solid organ transplant recipients, are at a heightened risk of encountering more severe consequences from COVID-19 (44). A study by Balcells et al. reported that solid organ transplant recipients exhibited a diminished humoral response to inactivated vaccines, and only 20% of vaccine recipients achieved antibody seropositivity (45). In a cohort study led by Naylor et al. in 2022, solid organ transplant patients were monitored following three doses of COVID-19 vaccination. The study revealed that after two doses, solid organ transplant recipients exhibited significantly lower vaccine effectiveness against clinically important outcomes than the general population. However, introducing a third dose enhanced vaccine effectiveness against infection and clinically important outcomes (46).

In this review, we discovered that mRNA vaccines exhibit robust efficacy in preventing SARS-CoV-2 infection, although their effectiveness may be slightly reduced in individuals with obesity. In this regard, previous studies indicate that the efficacy of mRNA vaccines ranged from 88% to 100% for the Alpha variant, 76% to 100% for Beta/Gamma, and 47.3% to 88% for Delta (47). Among viral vector vaccines, ChAdOx1 nCov 19 exhibited an effectiveness of 74.5% against the Alpha variant and 67% against the Delta variant (48, 49). Among inactivated virus vaccines, the use of CoronaVac or BBIBP-COrV in China was associated with an effectiveness of 59% (50). In a study conducted by Pellini et al., the antibody titers of individuals classified based on their weight status—healthy weight, overweight, or obesity—between the initial and subsequent doses of the BNT162b2 vaccine were explored. The results indicated that a single vaccination prompted a humoral immune response in healthy-weight patients, while overweight or obese participants (BMI > 25 kg/m2) did not demonstrate alterations in their IgG antibody levels (51). This might be explained by the influence of obesity in causing inflammation and immune dysfunction, affecting the immune response following vaccination and thereby reducing its effectiveness in providing protection (34).

While RNA-based vaccines boast the highest efficacy among existing vaccine modalities, it is essential to note that they are also linked to an increased risk of overall adverse events and local adverse events post-immunization. In a systematic review undertaken by Kouhpaye and colleagues, mRNA vaccines were found to be correlated with a heightened risk of any adverse events after immunization. Protein subunit vaccines demonstrated the highest risk of systemic adverse events, with mRNA vaccines following closely. Conversely, inactivated vaccines displayed the lowest relative risk for adverse and systemic adverse events (52). In another study

conducted by Castells et al., the occurrence of anaphylaxis after immunization with Pfizer-BioNTech and Moderna was documented to be roughly tenfold higher compared to previous vaccines (53). The elevated occurrence of adverse effects in mRNA vaccines can be linked to inactive components or byproducts present in the vaccine manufacturing process, including lipids or polyethylene glycol lipids. Individuals might exhibit heightened susceptibility to non-IgE-related mast-cell activation or complement activation (53, 54).

In a cohort study led by Gwak, pregnant women who received either mRNA or viral vector vaccines were assessed. In the unvaccinated group, there was a cumulative incidence of 6 ICU admissions per 100,000 within 14 days of SARS-CoV-2 infection. In contrast, the vaccinated groups showed no reported ICU admissions, which offers evidence concerning the efficacy and safety of COVID-19 vaccination before and during early pregnancy (55). In China, a parallel prospective cohort study was undertaken to assess the safety and effectiveness of the CoronaVac and BBIBP CorV vaccines in pregnant women. The findings affirmed the complete safety of these vaccines. The research demonstrated that inactivated COVID-19 vaccines were safe for both mothers and fetuses (56). Walter et al. conducted a randomized controlled trial involving 48 children aged 5-11 who received the BNT162b2 vaccine. The study results indicated that the COVID-19 vaccination regimen, consisting of two doses of BNT162b2 administered 21 days apart, was established as safe, immunogenic, and effective for children within the 5 to 11 years age group (57). Two RCTs were carried out involving children who received CoronaVac and BBIBP CorV. The findings from both studies demonstrated that these vaccines were well-tolerated, safe, and effectively induced humoral responses in children and adolescents (58, 59).

The results indicated that geographic and pandemic-related factors notably influenced vaccine acceptance. In a cross-sectional study conducted by Bono et al., acceptance of the vaccine was found to be higher among individuals who demonstrated greater knowledge about COVID-19, expressed increased concern or fear related to the virus, had a higher income, were younger, and tested negative for COVID-19.

Conversely, being female, having a chronic illness, having a lower level of education, and having a lower income were associated with a decreased likelihood of accepting the COVID-19 vaccine (60). The African countries displayed the lowest levels of vaccine acceptance (61). The widespread dissemination of false information on the internet during the pandemic presents a substantial threat to the willingness of people to accept vaccines. This risk is especially pronounced when obtaining accurate, evidence-based information is challenging (60). Given the fact that vaccine acceptance and the influencing factors can vary across different populations and settings, caution is needed when generalizing the findings of this review to other populations or settings.

This review suggested that SARS-CoV-2 vaccines are generally safe and effective across diverse populations, including children, pregnant individuals, and those with underlying health conditions such as IBD and solid organ transplant recipients or hematological malignancies. mRNA vaccines carry the highest efficacy despite an increased risk of adverse events post-immunization, whereas inactivated and protein subunit vaccines are generally regarded as safe with fewer adverse events. Finally, the results of this study demonstrated that various factors, including geographic and pandemic-related considerations, significantly influenced vaccine acceptance.

4.1. Limitations

In this study, there are several limitations worth mentioning, including incomplete data on vaccine safety for certain health conditions such as diabetes and hypertension, a focus on short-term effects, and potential confounding factors like geography and socioeconomic status influencing vaccine acceptance. Also, our study has limitations including the inherent risk of bias in design and execution, possible reporting bias in included studies, and potential incomplete retrieval of relevant research despite comprehensive search strategies. Future research ought to prioritize the analysis of long-term data to fill this knowledge gap. This can be achieved through conducting longitudinal studies with extended follow-up periods, enabling the monitoring of vaccine effectiveness and safety over time. Additionally, comprehensive consideration of confounding factors is imperative for a more robust assessment. Comparative evaluations of efficacy and safety among different types of COVID-19 vaccinations should be undertaken. Furthermore, diligent efforts should be made to mitigate bias through rigorous study design and meticulous data collection protocols.

5. Conclusion

The study outcomes indicated that mRNA vaccines exhibit a higher incidence of adverse events but demonstrate greater efficacy. Conversely, inactivated and protein subunit vaccines are safer but exhibit lower efficiency. Moreover, the vaccine is considered safe for individuals with specific conditions such as inflammatory bowel disease, solid organ transplant recipients, children, pregnant individuals, and those with hematologic problems. Ultimately, the acceptance of the COVID-19 vaccine among individuals is influenced by various factors, including geographic, socioeconomic, and pandemic-related considerations.

6. Declarations

6.1. Acknowledgments

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6.2. Data Availability

Data is available upon request.

6.3. Funding/Support

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

6.4. Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

6.5. Author contributions

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All authors read and approved the final version of manuscript.

6.6. Availability of data

The authors stated that all information provided in this article could be shared.

6.7. Using artificial intelligence chatbots

ChatGPT was used for checking grammar and the results classification.

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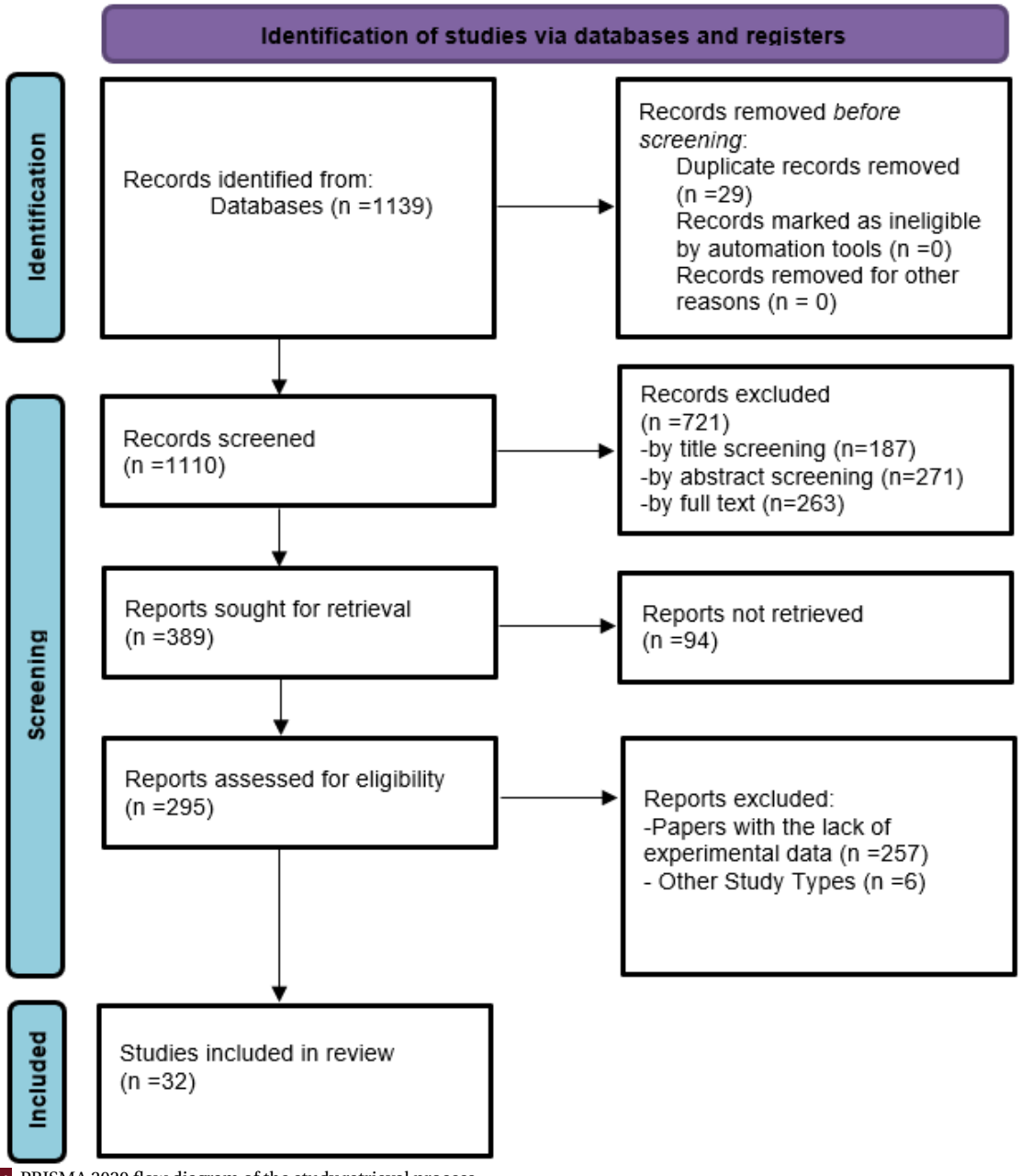

Figure 1: PRISMA 2020 flow diagram of the study retrieval process.

Table 1: Optimal database for literature searches in systematic reviews and meta-analysis reviews

Database	**Results (n=1139)**	
Database	Results (n=1139)	
PubMed	349	
Web of Science	217	**Includes (n=32)**
Scopus	405	
Embase	168	

Table 2: Methodological quality assessment using the ROBIS tool

Study ID	Phase 1	Phase 2																							Phase 3			Risk of bias
		Domain1						Domain2						Domain3						Domain4							Domain1	Domain2	Domain3	
		1	2	3	4	5	Concern	1	2	3	4	5	Concern	1	2	3	4	5	Concern	1	2	3	4	5	6	Concern				
1	Y	Y	Y	PY	PY	PY	Low	Y	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
2	Y	Y	Y	Y	Y	Y	Low	Y	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
3	Y	Y	Y	Y	Y	Y	Low	Y	N	PY	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
4	Y	Y	Y	Y	Y	Y	Low	Y	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
5	Y	Y	Y	Y	Y	Y	Low	Y	N	Y	Y	Y	Low	PY	Y	PY	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
6	Y	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
7	Y	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
8	Y	Y	Y	Y	Y	Y	Low	Y	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
9	Y	Y	Y	Y	Y	Y	Low	PN	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	PY	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
10	Y	Y	Y	Y	Y	Y	Low	Y	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
11	Y	Y	Y	Y	Y	Y	Low	Y	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
12	Y	Y	Y	Y	Y	Y	Low	Y	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
13	Y	Y	Y	Y	Y	Y	Low	Y	N	PY	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
14	Y	Y	Y	Y	Y	Y	Low	Y	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
15	Y	Y	Y	Y	Y	Y	Low	Y	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
16	Y	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
17	Y	Y	Y	Y	Y	Y	Low	Y	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
18	Y	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
19	Y	Y	Y	Y	Y	Y	Low	Y	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
20	Y	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
21	Y	Y	Y	Y	Y	Y	Low	Y	Y	Y	y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
22	Y	Y	Y	Y	Y	Y	Low	Y	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
23	Y	Y	Y	Y	Y	Y	Low	Y	Y	PY	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
24	Y	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
25	Y	Y	Y	Y	Y	Y	Low	Y	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
26	Y	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
27	Y	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
28	Y	Y	Y	Y	Y	Y	Low	PN	N	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
29	Y	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
30	Y	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
31	Y	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Low	Y	Y	Y	Y	Y	Y	Low	Low	Low	Low	Low
32	Y	Y	Y	Y	Y	Y	Low	y	Y	y	Y	Y	Low	y	Y	Y	Y	Y	Low	Y	y	Y	Y	Y	y	Low	Low	Low	Low	Low

Y=Yes; PY=probably yes; PN=probably no; N=No; NI=no information. *Each phase consists of one or several Domains, based on which standardization is defined for each of the included articles.

Table 3: Characteristics of the included studies

ID	The first author. year (reference)	Country	Type of review	Sources searched/ Search period	Number of studies included	Population	Sex (M/F)	Age (mean)	Purpose	Type of vaccine	Intervention	Outcome
1	Abhishek Bhurwal 2022, (15)	USA	Systematic Review, Meta-analysis and Meta-regression	PubMed MEDLINE, CINAHL and Cochrane CENTRAL from December 1, 2019 until December 25, 2021	21	Patients with IBD	NR	NR	the safety and effectiveness of SARS-CoV-2 vaccine in IBD.	BNT 162b2 Vaccine and mRNA-1273 vaccine Ad26.CoV2.S vaccine ChAdOx1n vaccines JNJ-78436735 vaccine	NR	SARS-CoV-2 vaccine is safe and effective in IBD patients.
2	Omid Dadras 2022, (36)	Iran	Systematic Review	PubMed, Scopus, Cochrane, and Web of Science were searched on September 15, 2021	19	Not Specified	NR	NR	adverse events reported for inactivated vaccines and Novavax	Sinopharm, Bharat, Perfusion S (preS) protein vaccine Vero Cells (Sinopharm) Sinopharm (38.2% of participants received Sinopharm 3.46% received Moderna, Sputnik, Covaxin & Johnson & Johnson Other58.34% received AstraZeneca &Pfizer)	NR	Inactivated COVID-19 vaccines, including Sinovac, Sinopharm, and Bharat Biotech, as well as the protein subunit vaccines (Novavax) can be considered as safe choices due to having milder side effects and fewer severe life-threatening adverse events
3	Orly Efros 2022, (23)	Israel	Systemic Review and Meta-Analysis	PubMed, EMBASE, and Web of Science	7	Adults who were solid organ transplant recipients	NR	NR	efficacy and safety of the third dose among solid organ transplant recipients.	mRNA-1273 (Moderna), mRNA-BNT162b2 (Pfizer/BioNTech), Ad26.COV2.S (50%) (J&J/Janssen),	NR	A third dose of the SARS-CoV-2 mRNA vaccine in solid organ transplant recipients is associated with improved immunogenicity and appears to be safe. Nevertheless, a significant portion of patients remain seronegative
4	Yu Jing Fan 2021 (62)	China	Systematic Review and Meta-Analysis	PubMed and EMBASE search	12	Not Specified	NR	NR	compare the safety and efficacy of 2019 novel coronavirus disease (COVID-19) vaccines according to vaccine platform and severe acute respiratory syndrome coronavirus 2 (SARS-COV-2) infection severity.	mRNA-1273, AZD1222, Gam-COVID-Vac, BNT162b2, Ad26.COV2. S,	NR	The results indicate that two mRNA vaccine doses prevent SARS-COV-2 infection most effectively

Table 3: Characteristics of the included studies (continue)

ID	The first author. year (reference)	Country	Type of review	Sources searched/ Search period	Number of studies included	Population	Sex (M/F)	Age (mean)	Purpose	Type of vaccine	Intervention	Outcome
5	Cangcang Fu 2023 (63)	China	Systematic Review	Embase, Medline Epub (Ovid), PsychInfo (Ovid), Web of Science, PubMed, CINAHL, and Google Scholar	15	People who were overweight or obese	NR	NR	appraise the interrelation between overweight/obesity and the safety and efficacy of COVID-19 vaccination by synthesizing the currently available evidence	BNT162b2 mRNA-1273 ChAdOxnCov-2019 BBIBP-CorV/CoronaVac Pfizer, Moderna, and AstraZeneca/ Vaxzevria Sinovac vaccine	NR	While the efficacy of the COVID-19 vaccine may be less than ideal in people who are overweight or obese, it does not mean that obese people should not be vaccinated, as the vaccine can still provide some protection.
6	Slawomir M Januszek 2021, (29)	Poland	Systematic Review	Pubmed studies published until July 10 2021	24	Pregnant women	NR	NR	concerning the approach of pregnant women towards vaccination against COVID-19, with particular regard to determinants of vaccination acceptance.	NR	NR	geographic factors (Asian, South American countries) and pandemic factors (different threats and risks from infection) significantly influence the acceptance of vaccines.
7	Salah Eddini Oussama Kacimi 2022, (39)	Algeria	Systematic Review	Medline inception to May 16, 2021	NR	Not Specified	46/54	64% were aged 18-29 years.	determinants of engagement toward the COVID-19 vaccine among the Algerian population.	NR	NR	The very low rates of vaccine engagement among the Algerian population probably explain the slow ascension of the vaccination curve in the country.
8	Meng LV 2021, (25)	China	Systematic Review	Medline (via PubMed), Web of Science, World Health Organization (WHO) COVID-19 database, and China National Knowledge Infrastructure (CNKI), from their inception to July 23 2021	Eight published studies with a total of 2852 children and adolescents and 28 ongoing clinical studies were included.	Children or adolescents (aged < 18 years)	NR	NR	To identify the safety, immunogenicity, and protective efficacy of COVID-19 vaccines in children and adolescents.	CoronaVac, BNT162b2	NR	Two COVID-19 vaccines have potential protective effects in children and adolescents, but awareness is needed to monitor possible adverse effects after injection.

Table 3: Characteristics of the included studies (continue)

ID	The first author. year (reference)	Country	Type of review	Sources searched/ Search period	Number of studies included	Population	Sex (M/F)	Age (mean)	Purpose	Type of vaccine	Intervention	Outcome
9	Chiara Primieri 2023, (38)	Italy	Rapid Systematic Review	PubMed	59	Italian population.	NR	NR	address the determinants of COVID-19 vaccination acceptance or hesitancy in the Italian population.	NR	NR	These findings should be considered to plan tailored interventions for counteracting COVID-19 vaccination hesitancy in Italy.
10	Rawal, S 2022 (30)	Georgia	Systematic Review	PubMed, Web of Science, CINAHL, and Google Scholar/ from January 1, 2020 through February 6, 2022	32	Pregnant people in the United States	NR	NR	To evaluate the safety, immune response, efficacy, and acceptance of COVID-19 vaccination among pregnant individuals in the United States.	Moderna (mRNA-1273), Pfizer-BioNTech (BNT162b2), Jcovden (JNJ-78436735)	Various Covid vaccine administrations	Peer-reviewed studies support COVID-19 vaccine safety and protective effects on pregnant people and their newborns.
11	Rinaldi, I 2022 (64)	Indonesia	Systematic Review and Meta-analysis	PubMed, Scopus, ScienceDirect, and EBSCO-Host (No limitation on the publication period)	15	Patients with hematological malignancies	58.7% M	Patients: median age range between 51 and 73 years Controls: NR	To statistically assess the effectiveness and safety of COVID-19 mRNA vaccines in individuals with blood-related cancers (hematological malignancies).	AstraZeneca, Pfizer-BioNTech (BNT162b2), oxford AstraZeneca (ChAdOx1 nCov-19, AZD1222), Moderna (mRNA-1273)	One or two doses of covid vaccine	- Cohorts with hematological malignancies exhibited lower seroconversion rates and antibody titers following COVID-19 mRNA vaccines. - The response to vaccination was significantly influenced by the type of malignancy and the treatment status. - The vaccines were found to be safe for both patients with hematological malignancies and healthy controls.
12	Sadeghi, S 2022 (26)	Iran	Systematic Review and Meta-analysis	Ovid Medline, Cochrane Library, Scopus, Web of Sciences, Embase, Google Scholar, and ClinicalTrials.gov website until December 7, 2021	22 + 2 RCT	Pediatric and adolescent population	NR	NR	To collect information regarding the effectiveness, safety, and immune response to COVID-19 vaccines in individuals between the ages of 2 and 21 years, with the aim of offering guidance to healthcare professionals and families.	mRNA, Viral Vector, Inactivated virus, recombinant adenovirus type-5 (Ad5), Plasmid DNA	NR	- Recent systematic review: Vaccines are safe for children and adolescents. - Occasional issues like myocarditis, but they resolved. - Vaccination for ages 2-21 is crucial to curb the pandemic. - Risk-benefit assessments support vaccination, even for those with underlying conditions or immunosuppression. - Meta-analysis results: - 91% vaccine efficacy after the first dose. - 92% vaccine efficacy after the second dose. - Overall immune response of 95%. - Pfizer vaccine demonstrated 91% effectiveness.

Table 3: Characteristics of the included studies (continue)

ID	The first author. year (reference)	Country	Type of review	Sources searched/ Search period	Number of studies included	Population	Sex (M/F)	Age (mean)	Purpose	Type of vaccine	Intervention	Outcome
13	Sandoval, C 2023 (35)	Chile	Systematic Review	Web of Science, Scopus, MEDLINE, EMBASE From January 2012 to November 2022	9	People over 18 years old	NR	NR	To clarify the effectiveness, immune response, and safety of novel vaccination technologies targeting SARS-CoV-2 in individuals aged 18 and above.	Moderna (mRNA-1273), Pfizer-BioNTech (BNT162b2), AstraZeneca (ChAdOx1 nCoV-19), BNT162b1, , Zifivax (ZF2001)	Random assignment to placebo or vaccine groups/	- mRNA, protein subunit, and viral vector vaccines are effective in reducing hospitalization and death in adults aged 18 and above after SARS-CoV-2 vaccination. - These vaccines offer protection against symptomatic disease. - They demonstrate good efficacy, safety, and immune response. - However, declining immunity and the development of SARS-CoV-2 variants contribute to reduced infection resistance over time.
14	Mehraeen, E 2022 (9)	Iran	Systematic Review	Scopus, PubMed, Cochrane, and Web of Science (Period NA)	74	Not Specified	NR	NR	To conduct a comprehensive review of adverse events associated with mRNA vaccines as documented in the available literature.	Pfizer-BioNTech, Moderna, BNT162b1	NR	- A direct relationship between vaccines and adverse events, except for myopericarditis, is not clearly established. - Severe adverse effects from COVID-19 vaccines are rare. - The benefits of vaccination in preventing severe COVID-19 and death outweigh the potential rare adverse events.
15	Sharif, N 2021 (8)	Bangladesh, Saudi Arabia	Systematic Review and Meta-analysis	MEDLINE (through PubMed), EMBASE, Web of Science, Scopus, The Lancet, The New England Journal of Medicine (NEJM) from December 15, 2019 to May 15, 2021	25	Not Specified	NR	NR	To analyze existing literature to assess the effectiveness, immune response, and safety of COVID-19 vaccines.	BNT162b1, Pfizer-BioNTech (BNT162b2), Moderna (mRNA- 1273), oxford AstraZeneca (ChAdOx1 nCov-19, AZD1222), Non-replicating adenovirus type 5 (Ad5)-vectored, Jcovden (Ad26.COV2. S), Gam-COVID-Vac (rAd26 and rAd5 vector-based heterologous prime Boost), Sinopharm (BBIBP-CorV), CoronaVac, MF59-adjuvanted spike glycoprotein-clamp, Novavax (NVX-CoV2373)	BNT162b2 vaccine; 2 doses/ ChAdOx1 nCoV-19 (AZD1222); 2 Doses/ rAd26 and rAd5 vector-based (Gam-COVIDVac); 2 doses/ ChAdOx1 nCoV-19 (AZD1222); 2 Doses/ Ad26.COV2. S; 1 Dose/ mRNA-1273; 2 Doses/ BNT162b2; 2 doses	- Adenovirus vector vaccines are 73% effective, while mRNA vaccines are 85% effective. - Over 90% of recipients developed neutralizing antibodies within 0-30 days of the first or second vaccine dose. - Common side effects: injection site pain (29%-85%) for mRNA vaccines, fever (0.2%-95%) for adenovirus vector vaccines, and fatigue (8.4%-55%) for mRNA vaccines. - Both vaccine types offer moderate to high protection for individuals aged 18 and older. - Limited data on long-term effectiveness in those under 16, especially against multiple variants.

Table 3: Characteristics of the included studies (continue)

ID	The first author. year (reference)	Country	Type of review	Sources searched/ Search period	Number of studies included	Population	Sex (M/F)	Age (mean)	Purpose	Type of vaccine	Intervention	Outcome
16	Shear, SL 2023 (17)	USA	Systematic Review	PubMed, EMBASE, Web of Science and Cochrane databases. from inception until November 2021	22	Patients with Solid Tumor Cancers	NR	NR	To establish the severity of side effects from the COVID-19 vaccine in individuals with solid cancerous growths.	Pfizer-BioNTech, Moderna, Vaxzevria (AstraZeneca), CoronaVac, CureVac	NR	- Common local symptoms: injection site pain and nearby lymphadenopathy. - Systemic effects: fatigue, musculoskeletal symptoms, and headaches. - Most side effects were mild to moderate. - Safety profile in patients with solid tumors is comparable to that in the general population, based on randomized controlled trials in the USA and globally.
17	Tan, S. Y. S. 2023 (18)	Singapore	Systematic Review	PubMed (from 1979), Embase (from 1981), Cochrane Central Register of Controlled Trials (CENTRAL), the World Health Organization International Clinical Trials Registry Platform (https://trialsearch.who.int/Default.aspx), and ClinicalTrials.gov (www.ClinicalTrials.gov). The databases were searched up to June 8 2022	32	Individuals with lupus nephritis or systemic lupus erythematosus (SLE) who were eligible for or received the COVID-19 vaccine	Predominantly female	49.0 ± 5.6 years	To evaluate the effectiveness, efficiency, acceptability, and safety of COVID-19 vaccination in individuals with systemic lupus erythematosus (SLE).	mRNA, viral vector, inactivated viral	NR	Following COVID-19 vaccination, cases of post-vaccine COVID-19 infection, severe flares, and adverse events were rare. However, there was notable variability in pooled seropositivity and acceptance rates.
18	Tang, K-T 2022 (19)	Taiwan	Systematic Review and Meta-analysis	EMBASE and MEDLINE from January 1 2020 to November 17 2021	47	Rheumatic patients	NR	NR	To provide a current assessment of the immune response, efficacy/effectiveness, and safety of COVID-19 vaccines in individuals with rheumatic conditions.	Vaxzevria (AZD1222), Pfizer-BioNTech (BNT162b2), Jcovden (Ad26.COV2.S), Moderna (mRNA-1273), CoronaVac, Convidecia, Covaxin	NR	- COVID-19 vaccination effectively protects rheumatic patients from severe illness. - Initial immune responses were lower but significantly improved after the second dose. - Patients on anti-CD20 therapy had reduced antibody responses. - Adverse events were similar to those in healthy individuals, with slightly more joint pain. - Disease flares after vaccination were infrequent.

Table 3: Characteristics of the included studies (continue)

ID	The first author. year (reference)	Country	Type of review	Sources searched/ Search period	Number of studies included	Population	Sex (M/F)	Age (mean)	Purpose	Type of vaccine	Intervention	Outcome
19	Teh, J. S. 2022 (16)	Australia	Systematic Review and Meta-analysis	MEDLINE, EMBASE, and Cochrane CENTRAL, from January 1, 2020, to August 31, 2021	44	Patients with hematologic malignancies who received at least 1 dose of COVID-19 vaccines	NR	NR	To evaluate the immune response and safety of COVID-19 vaccines in individuals with blood-related cancers (hematologic malignancies).	Pfizer-BioNTech (BNT162b2), Moderna (mRNA-1273), Vaxzevria (ChAdOx1), Jcovden (Ad26.cov2)	The administration of one or two doses of a COVID-19 vaccine (regardless of the specific type)	- After two COVID-19 vaccine doses, seropositivity rates ranged from 62% to 66%, with single doses resulting in rates of 37% to 51%. - The lowest seropositivity rate (51%) was observed in chronic lymphocytic leukemia patients, while the highest (93%) was seen in acute leukemia patients. - Neutralizing antibodies after two doses ranged from 57% to 60%, and cellular responses varied from 40% to 75%. - Poor responses were associated with recent treatment involving CD-20 monoclonal antibody therapies.
20	Yang X, H. 2023 (27)	China	Systematic Review and Meta-analysis	MEDLINE (PubMed, January 1, 2020, to December 31, 2022), Web of Science, EMBASE (January 1, 2020, to December 31, 2022), ClinicalTrials.gov, Cochrane Central Register of Controlled Trials	26	Adults greater than 60 years of age	from 30 to 95	age 60 years old (mean not reported)% men	To assess the effectiveness of COVID-19 vaccinations and their influence on breakthrough infections, hospitalization, and mortality in the elderly population.	Pfizer-BioNTech (BNT162b), Vaxzevria (ChAdOx1), Moderna (mRNA-1273), inactivated	Administration of 1,2, or 4 doses of covid vaccine regardless of the specific type	Vaccination with SARS-CoV-2 vaccines in the elderly is effective in preventing breakthrough infections, hospitalizations, reducing severity, and preventing deaths. - Increasing the Number of vaccine doses enhances effectiveness.
21	Barshan, AD 2024 (65)	Japan	Systematic Review and Meta-analysis	PubMed, EMBASE, and the World Health Organization COVID-19 Research Database, as well as other searches (i.e., reference list from article search and manual searches), from December 2020 to May 2022	39	Adult participants over 18 years with hematological malignancy and had received at least one dose of the COVID-19 vaccine.	NR	NR	evaluate the seroconversion rate of COVID-19 vaccines in patients with hematological malignancies compared with healthy controls.	BNT162b2, mRNA-1273, AZD1222, Ad26.COV2.S, ChAdOx1	First, second, or booster doses of COVID-19 vaccination	low seropositivity rates in patients with hematological malignancies, with substantial variations in rates across disease groups. The finLings emphasize the possibility of additional booster doses for these individuals to enhance their immunity against SARS-CoV-2.

Table 3: Characteristics of the included studies (continue)

ID	The first author. year (reference)	Country	Type of review	Sources searched/ Search period	Number of studies included	Population	Sex (M/F)	Age (mean)	Purpose	Type of vaccine	Intervention	Outcome
22	Cheng, M-q 2024 (37)	China	systematic review and meta-analysis	PubMed, Embase, Cochrane Library, and Web of Science	8	113,202 participants were included in the analysis, which incorporated 4 ACVs [Matrix-M (NVX-CoV2373), Alum (BBV152), CpG-1018/Alum (SCB-2019), and AS03 (CoVLP])	NR	NR	This study aimed to address this gap by conducting a systematic review and meta-analysis of the efficacy of ACVs against Severe Acute Respiratory Syndrome Coronavirus 2 CoV (SARS-CoV-2) variants of concern (VOC).	NVX-CoV2373, CoVLP, SCB-2019, BBV152	NR	it should be that full vaccination with ACVs has high efficacy against Alpha or Gamma variants and moderate efficacy against Beta and Delta variants. Notably, with the exception of the aluminum-adjuvanted vaccine, the other ACVs had moderate to high efficacy against the SARS-CoV-2 variant. This raises concerns about the effectiveness of ACVs booster vaccinations against Omicron.
23	Chirasuthat, S 2024 (20)	Thailand	Systematic Review and Meta-analysis	PubMed-MEDLINE, Scopus, and Embase, were searched for eligible articles published in November 2022	17	immune-mediated dermatological disease patients	NR	NR	This study aims to thoroughly examine vaccine immunogenicity, effectiveness, and safety in immune-mediated dermatological disease patients	BNT162b2, mRNA-1273, AZD1222, Ad26.COV2.S, heterogeneous vaccine	NR	immune-mediated dermatological diseases showed a reduced vaccine response in our meta-analysis, yet vaccination remained effective against COVID-19 infection and well tolerated.
24	Choi, S-H 2024 (66)	The Republic of Korea	Systematic Review of Randomized Controlled Studies and Observational Studies	ovid-MEDLINE, ovid-Embase, the Cochrane Library, and hand searching	17	the subjects included adolescents and children aged 12–17 years	NR	12-18	adverse events after COVID-19 vaccination in adolescents	mRNA-1273, BNT162b2	COVID-19 vaccination in adolescents	Our study showed that mRNA COVID-19 vaccines in adolescent recipients were favorable and effective against COVID-19 in RCT as well as observational studies. The safety findings of BNT162b2 vaccine in adolescents were explored and we found the difference of safety according to sex and vaccine doses. The occurrence of adverse events after mRNA COVID-19 vaccination should be monitored.

Table 3: Characteristics of the included studies (continue)

ID	The first author. year (reference)	Country	Type of review	Sources searched/ Search period	Number of studies included	Population	Sex (M/F)	Age (mean)	Purpose	Type of vaccine	Intervention	Outcome
25	Fernández-García, S 2024 (28)	United Kingdom	systematic review and meta-analysis	Medline, Embase, Cochrane database, WHO COVID-19 database, Living Overview of the Evidence platform, China National Knowledge Infrastructure and Wanfang databases for relevant studies on COVID-19 in pregnant women (1 December 2019 to 30 January 2023	66	women before or during pregnancy	1 813 947 women	NR	To assess the effects of COVID-19 vaccines in women before or during pregnancy on SARS-CoV-2 infection-related, pregnancy, offspring and reactogenicity outcomes.	mRNA, viral vector and inactivated virus vaccines	vaccination with any COVID-19 vaccine	COVID-19 vaccination in pregnant women is highly effective in reducing the odds of maternal SARS-CoV-2 infection, and hospital admission, and improves pregnancy outcomes, with no serious safety concerns. The interpretation of our findings may be impacted by changes in vaccine recommendations and the changing landscape of SARS-CoV-2 variants.
26	Glhoom, S 2024 (33)	Egypt	systematic review and meta-analysis	PubMed, Web of Science core collection, Scopus, and Cochran	24	immunocompromised patients	NR	aged12 years	The target of this review was to compare the efficacy of the two doses, 300 mg and 600 mg of tixagevimab/ cilgavimab (Evusheld) as prophylaxis for higher-risk individuals to reveal if there is a significant difference in efficacy between those two doses of the drug.	AstraZeneca, Sinovac, Sinopharm, Pfizer- BioNTech, Moderna	Administration of 300 mg and 600 mg of tixagevimab cilgavimab (Evusheld) as prophylaxis	This result indicated that Evusheld was an effective prophylactic and therapeutic drug for COVID-19 infection, especially for immunocompromised patients, but there was no considerable variation between the high and low doses. Further prospective and randomized controlled trials (RCTs) with increased population sizes are necessary to show the valuable benefit of the high dose of Evusheld in COVID-19 prevention and treatment and to compare the difference between the two doses within adverse events
27	Li, K 2024 (22)	China	systematic review and meta-analysis	PubMed ,Web of Science, Science Direct, and Cochrane Library from January 2019 until December 31, 2022	33	patients with CKD undergoing dialysis	NR	NR	the efficacy and safety of COVID 19 vaccine in the immune response of patients with chronic kidney disease (CKD) undergoing dialysis	BNT162B2, ChAdOx1-nCoV-19, mRNA 1273	NR	immune response of patients with CKD undergoing dialysis was effective, which indicated that COVID-19 vaccine injection can reduce the incidence of COVID-19 in patients. In addition, there were few common adverse events and there were no potentially vaccine-related serious adverse events. Therefore, the COVID-19 vaccine should be administered, considering the individual immune levels of patients.

Table 3: Characteristics of the included studies (continue)

ID	The first author. year (reference)	Country	Type of review	Sources searched/ Search period	Number of studies included	Population	Sex (M/F)	Age (mean)	Purpose	Type of vaccine	Intervention	Outcome
28	Ning, F 2023 (21)	China	systematic review and meta-analysis	including PubMed, Embase, and Web of Science, from January 01, 2020, to December 31, 2022.	28	individuals with autoimmune neurological disorders	NR	NR	This study evaluates the autoimmune neurological conditions safety of COVID-19 vaccines in the real world.	Mrna vaccine, inactivated vaccine, mix	NR	According to available evidence, the administration of COVID-19 vaccines in individuals with autoimmune neurological disorders seems well-tolerated, with few reports of adverse events. Furthermore, exacerbation of autoimmune neurological conditions following vaccination appears to be infrequent.
29	Rubin M 2024 (24)	United States	Systematic Review and Meta-Analysis	Ovid MEDLINE, Scopus, Web of Science, Cochrane Central, medRxiv, and preprint servers	7	Allogeneic Hemopoietic Stem Cell Recipients	NR	NR	we investigated the efficacy of a third dose of SARS-CoV-2 vaccine in alloHCT recipients	Pfizer x 3 Moderna x 3	received 3 doses of SARS-CoV-2 vaccine	In conclusion, the pooled humoral response rate of 74% following three doses of SARS-CoV-2 vaccine in alloHCT recipients highlights the potential for protection in this immunosuppressed population. Additionally, encouraging responses in nearly half of the patients who did not seroconvert with the initial 2-dose series suggest the continued utilization of additional vaccine doses until results from large prospective studies become available. These findings are critical for inform
30	Santimano, AJ 2024 (31)	Qatar	Systematic Review and Meta-Analysis	PubMed, Scopus, and EMBASE databases for research publications published between December 2019 and October 2021	11	Pregnant women	100% women	32.2	This review aimed to provide healthcare workers and non-healthcare workers with a comprehensive overview of the available information regarding the efficacy of vaccines in pregnant women	mRNA- containing lipid nanoparticle vaccine from Pfizer/ BioNTech and Moderna	vaccination with mRNA-containing lipid nanoparticle vaccine from Pfizer/ BioN-Tech and Moderna during pregnancy	The systemic side effect profile after administering the COVID-19 mRNA vaccine to pregnant women was similar to that in nonpregnant women. Maternal and fetal morbidity and mortality were lowered with the administration of either one or both the doses of the mRNA COVID-19 vaccination.
31	Song, G 2024 (67)	China	systematic review and meta-analysis	EMBASE, Cochrane, PubMed, and Web of Science up to 10 March 2024	15	Adults greater than 18	NR	>18	This study aimed to examine the safety, immunogenicity and protective effective of inhaled COVID-19 vaccines (ICVs).	AAd5-nCoV, IMAd5-nCoV, denoviral vector vaccine (ChAdOx1 nCoV-19, dNS1-RBD	Vaccination with inhaled COVID-19 vaccines	Current evidence shows that the safety profile of ICVs were well. Although the immunogenicity and protective effective of ICVs appear weaker in PVs, ICVs as booster doses exhibit higher levels of immunogenicity (including mucosal immunity) and can induce protection against COVID-19 caused by the SARS-CoV-2 omicron subvariant. ICVs may provide an effective alternative to address the spread of the Omicron variant.

Table 3: Characteristics of the included studies (continue)

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32	Tamb, BMMAR 2024 (32)	China	systematic review and meta-analysis	PubMed, Cochrane Library, MEDLINE, and Embase to identify all published studies on CKD patients who had received three doses of COVID-19 vaccine up to January 31, 2022	20	Patients Receiving Renal Replacement Therapy	NR	NR	We conducted a meta-analysis on the immunogenicity and safety of three-dose COVID-19 vaccination in patients on renal replacement therapy (RRT)	mRNA vaccines	Three-dose COVID-19 vaccination regimen	Three-dose COVID-19 vaccination regimen in patients on RRT is associated with reduced immunogenicity, especially in KTRs. There are no adverse events associated with third-dose COVID-19 vaccine

Note Alhumaid , S (Alhumaid , Saad), Bhurwal, A (Bhurwal, Abhishek), Dadras, O (Dadras, Omid), Efros ,O (Efros, Orly), Fan, Y-J (Fan, Yu-Jing), Fu, C (Fu, CangCang), Januszek, SM (Januszek, Slawomir M), Kacimi, SEO (Kacimi, Salah Eddine Oussama), Lv, M (Lv, Meng), Megnin-Viggar, O(Megnin-Viggars, Odette), Primieri, C (Primieri, Chiara) Rawal, S (Rawal, Smita), Rinaldi, I (Rinaldi, Ikhwan), Sadeghi, S (Sadeghi, Sara), Sandoval, C (Sandoval, Cristian), SeyedAlinaghi, SA (SeyedAlinaghi, SeyedAhmad), Sharif, N (Sharif, Nadim), Shear, SL (Shear, SL), Tan, S. Y. S. (Tan, Shaun Ye Song), Tang, K.-T. (Tang, Kuo-Tung), Teh, J. S. (Teh, Joanne SK), Yang, X. H. (Yang, Xiu Hong), Barshan, AD (Barshan, Anindita Das), Cheng, M-q (Cheng, Meng-qun MA), Chirasuthat, S (Chirasuthat, Sonphet), Choi, S-H (Choi, Soo-Han), Fernández-García, S (Fernández-García, Silvia), Glhoom,S (Glhoom, Shaymaa) Li, K (Li, KEJIA), Ning, F (Ning, Fan), Rubin M (Rubin, Micah), Santimano, AJ (Santimano, Antonio J), Song, G (Song, Gao), Tamb, BMMAR (Tamb, Becky Mingyao Maa Anthony Raymond) IBD (inflammatory bowel diseases), UK (United Kingdom), USA (United States of America), F (Female), M (Male), NR (Not Reported), RCT (Randomized Clinical Trial), COVID-19 (Coronavirus Disease 2019), SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2), ACVs (adjuvant-associated COVID-19 vaccines), ICVs (inhaled COVID-19 vaccines).