Received: 29 May 2022 | Revised: 2 July 2022 | Accepted: 18 July 2022

DOI: 10.1111/jocd.15261

JCD Journal of Cosmetic Dermatology WILEY

REVIEW ARTICLE

Cutaneous adverse reactions following COVID-19 vaccinations: A systematic review and meta-analysis

Mohammad Shafie'ei MD[1] | Marzieh Jamali MD[2] | Zahra Akbari MS[1] | Nastaran Sarvipour MS[1] | Mohadese Ahmadzade MD[3] | Najmeh Ahramiyanpour MD[4]

[1]Faculty of Medicine, Kerman University of Medical Sciences, Kerman, Iran

[2]Gene Therapy Research Center, Digestive Diseases Research Institute, Tehran University of Medical Sciences, Tehran, Iran

[3]Departments of Plastic Surgery, Shahid Beheshti University of Medical Sciences, Tehran, Iran

[4]Department of Dermatology, Afzalipour Hospital, Afzalipour Faculty of Medicine, Kerman University of Medical Sciences, Kerman, Iran

Correspondence
Najmeh Ahramiyanpour, Department of Dermatology, Afzalipour Hospital, Afzalipour Faculty of Medicine, Kerman University of Medical Sciences, Kerman 7616913555, Iran.
Email: najmeh.pour@gmail.com

Abstract

Background: COVID-19 vaccines are currently the most effective interventions in controlling and preventing severe disease progression. Dermatologic reactions to COVID-19 vaccinations may be rare among clinical trial participants. However, since global mass vaccination became a reality, these adverse effects may become more widespread, and different skin reactions would arise.

Objective: To systematically review the cutaneous adverse reactions in cases subject to vaccines for COVID-19.

Methods: We searched the PubMed, SCOPUS, Web of Science, and Embase databases, identifying the relevant records and including the eligible observational ones. After assessing the methodological quality of the included studies, we qualitatively and quantitatively synthesized the data regarding the cutaneous side effects experienced by those in the studies' population.

Results: Overall, 36 studies were included in our systematic review, with the majority being cross-sectional. We found that pain, erythema, and swelling were the most common local side effects, while different types of rashes, urticaria, and angioedema were the most non-local. Few cases also reported experiencing flare-ups of their underlying diseases or developing newly-onset diseases of various etiologies. Our meta-analyses also found that while viral vector-based vaccines are, though insignificantly, safer in injection site complaints, individuals who received mRNA vaccines developed significantly fewer non-local cutaneous adverse events.

Discussion: Cutaneous reactions to the COVID-19 vaccines are similar to common cutaneous drug eruptions and COVID-19 cutaneous manifestations. However, we believe that further high-quality research is needed to assess better how and why cutaneous reactions occur in different vaccines.

KEYWORDS
COVID-19, cutaneous, skin, vaccination

1 | INTRODUCTION

With the coronavirus outbreak in 2019 (COVID-19), the world is facing a new challenge. Public health strategies have significantly impacted controlling and managing the epidemic but have not been sufficient to reduce the impact of the disease.[1]

Vaccination is currently the most effective intervention to control and prevent epidemics, severe disease progression, hospitalization, and reduce mortality.[2–4] Many different types of COVID-19 vaccines with various platforms are currently available or being investigated, 167 of which are in the clinical development phase or have passed it to the global distribution phase, according to the World Health Organization (WHO).[5] The platform these candidates have been developed on include, Protein subunit, Viral Vector (non-replicating; VVnr), DNA, Inactivated Virus, RNA, Viral Vector (replicating; VVr), Virus-Like Particle, VVr plus Antigen Presenting Cell, Live Attenuated Virus, VVnr plus Antigen Presenting Cell, and Bacterial antigen-spore expression vector.[5] The two primary COVID-19 vaccines currently considered the most effective and widely utilized are the Messenger RNAs (mRNAs; e.g., Pfizer-BioNTech and Moderna) and those with Viral vectors (e.g., Johnson & Johnson's Janssen and AstraZeneca).[6]

As with other medications and vaccines, some people may have mild to moderate side effects following vaccination with COVID-19. Common side effects following injection of COVID-19 vaccines include fever, fatigue, headache, muscle aches, chills, diarrhea, and pain or redness at the injection site.[2] Most of these common vaccine-related side effects subside after a few days.[2] Nevertheless, a few side effects are more severe and may occur long-term.

Dermatologic reactions to COVID-19 vaccinations may be rare among clinical trial participants. However, since global mass vaccination became a reality, adverse effects may become more evident and include a spectrum of skin reactions not initially recognized. Therefore, dermatologists are concerned with the rising number of reports of cutaneous responses linked to these immunizations.

According to our literature review, the most common cutaneous side effects following COVID-19 vaccination were local reactions at the injection site, such as erythema, swelling, tenderness, pain, stiffness, and itching within7 days of injection.[3,4,7] Significant delayed local reactions, typically starting 8 days or more after vaccination and consisting of erythema, stiffness, and tenderness. In addition, although rare, many other dermatologic manifestations with varying severity, such as Allergic, atopic, and contact dermatitis; eczema; exfoliative rash; hypersensitivity reactions; injection site urticaria; papular urticaria; and vesicular rash have been reported.[3]

As a result, physicians must be aware of and understand the cutaneous adverse effects of licensed vaccines to educate patients better and provide appropriate counseling. Moreover, an Increased understanding of these manifestations can aid dermatologists in identifying potential hazards, providing proactive advice, and initiating appropriate treatment. For this reason, we have performed a comprehensive review to determine the global landscape of COVID-19 vaccine-related dermatologic adverse effects.

2 | METHODS

We conducted our systematic review while fully adhering to the guidelines available at the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (http://www.prisma-statement.org/).[8]

2.1 | Search strategy

To identify the published studies of interest, we prepared a search strategy comprising strings of keywords related to our study's objectives, provided as Appendix S1. Next, the PubMed, SCOPUS, Embase, and Web of Science databases were systematically searched for record identification.

2.2 | Eligibility criteria

In order to appropriately investigate the identified studies for eligibility, we considered a framework for the investigation of risk of exposures with health outcomes in studies, known as PECO (Population, Exposure, Comparator, Outcomes).[9]

2.2.1 | Study type

We only considered English observational studies (i.e., case–control studies, cohorts, and cross-sectional studies) that investigated experienced cutaneous adverse events following the COVID-19 vaccination approved by the World Health Organization (WHO). Therefore, all interventional studies (Vaccine Trials), case series, case reports, letters to the editors, meeting and conference abstracts or proceedings, editorials, and reviews were excluded.

2.2.2 | Population

The population in our study were individuals whose cutaneous reactions from COVID-19 vaccines were reported. We did not apply any limits on these individuals' age, sex, nationality, ethnicity, or race or whether they had any medical comorbidities or underlying diseases.

2.2.3 | Exposure

The exposure of our interest was any of the vaccines regarded by the WHO as scientifically approved. However, the two vaccine types

with the highest efficacy (i.e., mRNA and viral vector-based) were more highly considered.

2.2.4 | Comparator

Even though we regarded the presence of a comparator group as a bonus, whether a study had any control groups was not applied to limitations.

2.2.5 | Outcome

The incidence and the type of any cutaneous side effects was of our primary interest. We, therefore, divided these side effects into two groups based on localization, with local side effects reflecting those occurring at the injection site (e.g., pain, erythema, swelling, or COVID arm in general) and non-local side effects reflecting those that occurred elsewhere (e.g., non-urticarial rash, urticaria, or angioedema).

2.3 | Study selection

The study selection, quality assessment, and data extraction were carried out under the supervision of the senior author. We initially collected the identified records from the four mentioned databases and checked for duplicates using the 20th version of the Endnote software package. Then using the duplicate removal tool provided by Rayyan Incorporation,[10] any remaining duplicate records were manually removed. Next, two authors independently screened the resulting studies based on their titles and abstracts, removing those deemed irrelevant. Two authors independently screened the records passing through the first round based on their full texts, excluding the ineligible studies.

2.4 | Data extraction

Two authors independently extracted the data from the eligible studies using a prespecified flexible data extraction form. These data include The study's first author, country, year it was conducted in, type, the investigated vaccine, and its dose, total number, mean age, and sex of vaccinated cases, along with their past medical and allergic history, number, mean age, and sex of patients with cutaneous manifestations from each of the vaccines and their presentation, cases with a history of COVID-19 infection and, if positive, their cutaneous manifestations following the infection, the timing between receiving the vaccine injection and the manifestations, and finally, the number of cases with a flare of their underlying dermatologic condition. The data were then used for qualitative synthesis based on their reports of local and non-local cutaneous reactions (i.e., adverse events).

2.5 | Quality assessment

The quality of the included studies was assessed by utilizing the tools recommended by the Joanna Briggs Institute (JBI; available at https://jbi.global/critical-appraisal-tools). Needless to say, the mentioned tools for the critical appraisal of cohorts, case–control studies, and cross-sectional studies comprised 11, 10, and 8 items, respectively.

2.6 | Statistical analysis (meta-analysis)

The analysis of the overall risk of developing cutaneous side effects was not practically possible due to the absence and, possibly, the impracticality of including and evaluating control groups in most of the included studies. Therefore, we conducted a meta-analysis of the available data based on the risk of developing cutaneous local (studies that reported an aggregate of the number of cases with complaints of pain, swelling, or erythema) and systemic (rash as one and urticaria-angioedema as one due to their relative similarity in appearance and pathophysiology) side effects in individuals who received mRNA and viral vector-based vaccines. The confidence level was 95%, and *p*-values smaller than 0.05 were considered statistically significant. Furthermore, we found that the included studies' methods of sampling and data collection differed considerably (some via subjective reports of the individuals and some via direct examination of the lesions). Therefore, the meta-analysis objective was achieved by utilizing the random-effects model from the restricted-maximum likelihood formula for estimating the risk ratio as the intended effect size. The investigation of publication bias was also carried out using Egger's method.

Any existing disparities between studies were evaluated by calculating heterogeneity using the I^2 and χ^2 statistics, according to which heterogeneity greater than 75% for I^2 and χ^2 p-value <0.05 is considered substantial. In these instances, we opted to investigate why the heterogeneity is high.

3 | RESULTS

We identified 1772 studies through our systematic search of the four databases, 953 of which were duplicates, and therefore, were removed. Sixty-four studies were also excluded at first glance due to being editorials, letters to the editors, reviews, or conference or meeting abstracts or proceedings. Moreover, 707 and 12 studies were excluded in the first and second rounds of screening, respectively, with the latter being due to reasons including ineligible design, not describing the cutaneous reactions separately, letters to the editors, or primarily investigating the results of skin testing rather than manifestations following the vaccination. Therefore, 36 studies were included in our qualitative synthesis. Furthermore, six studies were included in one of the meta-analyses (Figure 1).

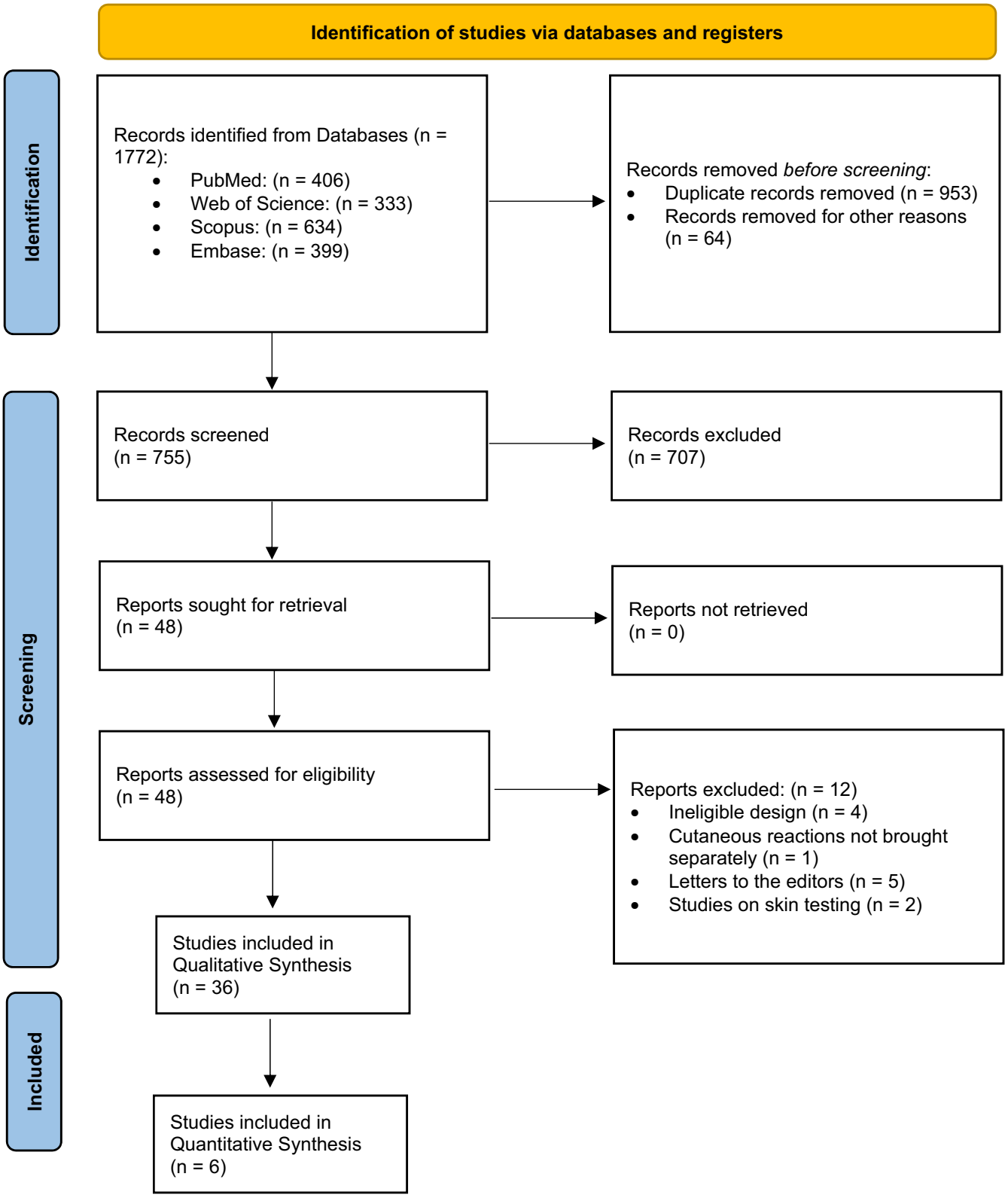

FIGURE 1 Systematic review flow diagram

The majority of studies were cross-sectional in design (22 studies),[11–32] followed by cohort (13 studies[33–45]) and case–control (one study[46]) studies, respectively. Most of the studies were carried out in Europe (14 studies), followed by Eastern Asia (6 studies), Western Asia (5 studies), North America (4 studies), and South America (2 studies), respectively. Furthermore, five studies were carried out in multiple nations. Except for one study in 2020, the remaining were conducted in 2021.

3.1 | Quality assessment

We found that the included studies had methodological quality ranging from moderate to high, with most falling around moderate. Moreover, the detailed assessment of the studies is brought in Appendix S2.

3.2 | Qualitative synthesis

In general, 680 566 cases were evaluated following their COVID-19 vaccination. Of those whose vaccine dose was explicitly specified, 604 124 cases (94.7%) received their first dose, and 33 553 cases received their second dose (5.3%). Regarding the vaccine type, 314 621 (46.9%), 351 105 (52.3%), and 5462 (0.8%) cases received mRNA, Viral vector-based, and Inactivated protein vaccines, respectively.

We found that regarding the local side effects, the most common reports after the injection of either the 1st or the 2nd dose in order of frequency were pain (i.e., experiencing on-site pain immediately or a few hours to days after the injection; more than 111 400 incidences), localized edema (i.e., visible entrapment of fluid in the injection site; more than 27 200 incidences), and erythema (i.e., local redness of the injection site without being accompanied by a rash; more than 19 300 incidences), among others, including COVID arm (a delayed local hypersensitivity reaction occurring around the injection site, manifesting with an itching erythematous induration[47]), and pruritis. However, the reviewed studies did not perform a histopathologic examination of the lesions, confirming their diagnosis based on their clinical features (Table 1).

Moreover, non-local side effects were not exclusive to any body parts, with every part affected in all cases with such complaints. These adverse events were mainly mild to moderate, rarely requiring hospitalization and dedicated intensive therapy.[15,17,23,26,37,43] Those with severe grades requiring hospitalization also only received the standard therapy (e.g., immunosuppression with corticosteroids) until the manifestation subsided for a safe discharge. Therefore, no targeted treatment was initiated in any of the mentioned cases, and the majority also proceeded to receive the vaccine doses next in line (i.e., second or third doses, respectively). However, a few could not receive the vaccine due to the severe reactions their body had towards the received vaccine, indicated after the necessary allergy assessment tests were performed.

As demonstrated in Table 1, regarding non-local side effects (i.e., skin rash and urticaria/angioedema), cutaneous rashes manifesting in several types and forms (i.e., morbilliform, pityriasis rosea-like, papulovesicular, toxic erythema, erythema multiforme, Stevens–Johnson syndrome, lymphomatoid drug eruption, erythema nodosum, annular lichen planus, genital fixed drug eruption, generalized erythema and pustules, purple acral nodules, eczematous rash, Erythromelalgia, the vaccine-related eruption of papules and plaques, bullous pemphigoid-like, leukocytoclastic vasculitis), were the most common adverse event, with more than 3100 reports. Only in studies by Niebel et al., MacMahon et al., and Magro et al. were these lesions pathologically confirmed,[23,24,32] while the rest of the studies reporting these incidents did so either by filling a questionnaire or by direct clinical or photographic examination.[15,22,25,36,46]

Next in line of frequency was either urticaria or angioedema, with the two complications occurring in more than 1720 individuals. There were also reports of unspecific generalized pruritis (21 incidents) and cosmetic injected filler reactions (10 incidents), requiring medical attention and extraction. These manifestations were diagnosed clinically and not via pathology.

Furthermore, reports indicated the reactivation of varicella-zoster and herpes viruses in 55[15,20,22,25] and 24[11,15,22,46] cases, respectively. Furthermore, there were reports of underlying disease flare-ups manifesting on the skin in 46 cases, 27 (58.7%) of which were due to systemic lupus erythematosus, 9 (19.6%) were due to psoriasis, 4 (8.7%) due to lichen planus, 2 (4.3%) due to atopic dermatitis, 2 (4.3%) due to unspecified eczema, 1 (2.2%) due to sarcoidosis, and 1 (2.2%) due to vasculitis.[15,22,24,31,46] Except for the two with eczema, the other cases were histopathologically confirmed if required.

Moreover, there were 6 cases with manifestations of a new-onset and clinically or histopathologically (as required) confirmed disease, which in order of frequency were unspecified eczema (7 cases), Raynaud's phenomenon (4 cases), psoriasis (4 cases), acute generalized exanthematous pustulosis, bullous pemphigoid, and erythema multiforme (2 cases each, respectively), generalized morphea, cutaneous B-lymphoma, Grover disease, erythema nodosum, staphylococcal skin infection, and lichen planus (1 case each, respectively).[15,22,32]

3.3 | Meta-analysis

Local side effects between the mRNA and VV vaccines were compared in three studies, the results of which were pooled and led to an overall estimated risk ratio (RR) of 1.08, slightly more common in the former and statistically insignificant (p-value = 0.84, CI = [0.52–2.26]). Moreover, these findings are relatively unreliable due to the high heterogeneity between the studies (I^2 = 91.08%, χ^2 p-value < 0.001) and the statistical significance of publication bias (p-value = 0.0384; Figure 2).

Regarding primary non-local side effects, the pooled data of the five eligible studies pointed towards a higher statistically significant risk in the VV vaccine group, with those vaccinated in this group at approximately 36% (RR = 0.64; CI = [0.6–0.68]; p-value < 0.001) more susceptible to developing rash, urticaria, or angioedema (Figure 3).

The risk of developing rash (RR = 0.61; CI = [0.56–0.66]; p-value < 0.001) and urticaria-angioedema (RR = 0.69; CI = [0.62–0.76]; p-value < 0.001) were also analyzed separately which also revealed statistical significance, with individuals receiving VV

TABLE 1 Included studies' bibliographic and demographic data in brief

Study	Country	Design	Sample age (Mean ± SD/ range) (years)	Sample sex	Number of cases with cutaneous manifestations	Cutaneous manifestation type	Vaccine type
Abu-Hammad et al. (2021)[11]	Jordan	Cross-Sectional	Dose 1: 34.99 ± 12.07 Dose 2: 39.27 ± 12.79	Dose 1: [M: 120/F: 298], Dose 2: [M: 67/F: 128]	Dose1: (302 pain, 61 numbness, one herpes zoster reactivation, one redness, one urticaria). Dose 2: (112 pain, one herpes zoster reactivation)	Herpes zoster/Redness and swelling (injection site)/ Urticaria/injection site pain/numbness injection site	mRNA, Viral-Vector based, and Inactivated
Al Bahrani et al. (2021)[12]	Saudi Arabia	Cross-Sectional	37.4 ± 9.6 Range: 19–83	M: 1290 F: 302	307 rash, 485 Injection site pain	Skin rash/pain at the site of injection	Viral-Vector Based
Al Khames Aga et al. (2021)[13]	Iraq and Jordan	Cross-Sectional	Range: 18–86 IQR: 26–74	M: 896 F: 840	600 (34.56%)	pain, redness, urticaria, swelling, itch	mRNA, Viral-Vector based, and Inactivated
Alhazmi et al. (2021)[14]	Saudi Arabia	Cross-Sectional	26 ± 9 Range: 18–70	F: 294 M: 221	261	Pain or redness at the site of injection	mRNA and Viral-Vector based
Amer et al. (2021)[33]	Pakistan	Cohort	Not specified	M: 114 F: 41	Injection site pain (36.8%), Localized Erythema (5.2%), Itching (<4%)	Redness at site of injection (5.2%)/itching and swelling at injection site (<4%)/pain at injection site (36.8%)	Inactivated
Burl et al. (2021)[46]	Italy	Case–Control	Not specified	F: 116 M: 84	21 (10.5%)	Bullous erythema multiforme/macular-papular or urticarial reactions/pityriasis rosea of gibert/ orange plaques/sarcoidosis/echymosis/eruptive angiomas/giant seborrheic keratosis/lichen planus plaques/psoriatic plaques/rash/facial swelling	mRNA and Viral-Vector based
Català et al. (2021)[15]	Spain	Cross-Sectional	50.7 ± 17.6 Range: 20–95	Pfizer: [F: 114, M: 49] Moderna:(F: 133, M: 14) AstraZeneca: (F:78, M:17)	391	Injection site (COVID arm), erythematous patches or swollen plaque at the injection site, urticaria or angioedema, erythematous maculopapular rash reminiscent of measles, morbilliform, papulovesicular/pseudo vesicular, pityriasis rosea-like, and purpuric reactions. Varicella-zoster and herpes simplex virus reactivations, scaly oval-shaped plaques, purpuric rashes, itch, pain, stinging, burning	mRNA and Viral-Vector based

TABLE 1 (Continued)

Study	Country	Design	Sample age (Mean ± SD/ range) (years)	Sample sex	Number of cases with cutaneous manifestations	Cutaneous manifestation type	Vaccine type
Choi et al. (2021)[16]	South Korea	Cohort	Range: 75–102	1st dose: [M: 940, F: 1183] 2nd dose: [M: 936, F: 1169] Surveyed 1st dose: [M: 283, F: 355] 2nd dose: [M: 259, F:321]	Erythema: [1st dose: 1, 2nd dose: 6] Swelling: [1st dose: 23, 2nd dose: 28] Pain: [1st dose: 315, 2nd dose: 248] Skin rash/Urticaria: 3	Erythema, swelling, urticaria, pain, skin rash	mRNA
Cugno et al. (2021)[34]	Italy	Cohort	Subjects Taking ACE Inhibitor Therapy: 55.3 Subjects not Taking ACE Inhibitor Therapy: 42.9	Subjects not Taking ACE Inhibitor Therapy [F: 2515, M: 1008] Subjects Taking ACE Inhibitor Therapy [F:42, M: 21]	65 [Taking ACEI: 61 Not taking ACEI: 4]	Urticaria/Angioedema	mRNA
Cuschieri et al. (2021)[17]	Malta	Cross-Sectional	Not specified	F: 987 M: 493	1st dose: 544 2nd dose: 302 Both doses: 743	Redness and swelling at injection site/Pain at the injection site	mRNA
Elnaem et al. (2021)[18]	Malaysia	Cross-Sectional	Not specified	F: (66.4%)	Redness: 7.5%; Itching: 8.3%; Pain & Swelling at Injection Site: 61.1%		
Golan et al. (2021)[35]	Italy	Cohort	35.7 ± 3.9	F: 48	0	Rash in other places 0, Injection Site: 1st dose: Pain 42, Redness 2, Swelling 8, Itching 2, Rash 1; 2nd dose: Pain 41, Redness 5, Swelling 8, Itching 2, Rash 2	mRNA
Grieco et al. (2021)[36]	Italy	Prospective Observational	Mean: 47 Range: 22–76	M: 20 (40%) F: 30 (60%)	50 subjects [1st dose: 28, 2nd dose: 20, Both doses: 2]	Localized injection-site erythema:12 (24%)/ generalized cutaneous reactions: 38 (76%); urticarial rashes and/or angioedema: 14 (28%), generalized pruritus: 5 (10%), toxic erythema:4 (8%), erythema multiforme: 3 (6%), pityriasis rosea-like eruption: 3 (6%), Stevens–Johnson syndrome: 1 (2%), morbilliform drug exanthema: 1 (2%), lymphomatoid drug eruption resembling PLEVA: 1 (2%), erythema nodosum: 1 (2%), late-onset atopic dermatitis: 1 (2%), annular lichen planus: 1 (2%), pseudo-chilblain relapsing with necrotic features at the second dose: 1 (2%), filler injection-site reaction: 1 (2%),genital fixed drug eruption: 1 (2%)	mRNA and Viral-Vector based
Im et al. (2021)[37]	South Korea	Cohort	Not specified	Not specified	1st dose 43 2nd dose: 50	Redness, swelling, pain, itching urticaria	

(Continues)

TABLE 1 (Continued)

Study	Country	Design	Sample age (Mean ± SD/ range) (years)	Sample sex	Number of cases with cutaneous manifestations	Cutaneous manifestation type	Vaccine type
Jeon et al. (2021)[38]	South Korea	Cohort	35.7 Range: 19–63	F: 1st dose = 762 (76.7%) 2nd dose = 559 (76.9%)	Redness: (Dose 1339, Dose 2190) Tenderness: (Dose 1: 484 Dose 2: 239)		Viral-Vector based
Jęśkowiak et al. (2021)[19]	Poland	Cross-Sectional	Ages Over 18	F: 79% M: 21%	1st dose: 13, 2nd dose: 15	1st dose: Injection site soreness 1253, 392 swelling, 295 redness, 89 pruritis,13 hair loss; 2nd dose: 1008 site pain, 317 swelling, 259 redness, 76 pruritis, 15 hair loss, 268 soreness, 73 swelling, 51 redness, 24 pruritis	
Kadali et al. (2021)[20]	USA	Cross-Sectional	43	F: 86.55%	2 (0.25%)	arm pain 707, swelling 44, Itching 43, rash 20, residual discoloration 10, local hair loss 1, numbness 23, hives 5, Atopic eczema *n* = 2 (0.25%)	mRNA
Kaplan et al. (2021)[39]	USA	Cohort	48 Range: 19–89	F: 86.7%	47% (7/15) of the males and 15%(15/97) of the females with non-urticarial reactions		mRNA and Viral-Vector based
Klugar et al. (2021)[21]	Germany	Cross-Sectional	Not specified	Out of the 474 mRNA-based vaccine recipients, F: 73.6% Out of the 125 viral vector-based vaccine recipients, F: 67.2%	Local: mRNA: 371; Viral-Vector based: 88 (70.4%) Total: 459 (76.6%) Non-Local: mRNA: 14 (3%) Viral-Vector based: 7 (5.6%) Total = 21 (3.5%)	Injection Site Pain mRNA 367 (77.4%) Viral Vector 86 (68.8%): Total 453 (75.6%) Injection Site Swelling mRNA 88 (18.6%) Viral Vector 20 (16%): Total 108 (18%) Injection Site Redness 51 (10.8%) 11 (8.8%) 62 (10.4%); Rash: mRNA = 12 (2.5%) viral = 5 (4%) total = 17 (2.8%) Urticaria: mRNA = 2 (0.4%) viral = 2 (1.6%) total = 4 (0.7%) Angioedema: mRNA = 2 (0.4%) viral = 2 (1.6%) total = 4 (0.7%) total: mRNA = 14 (3%) viral = 7 (5.6%) Total = 21 (3.5%)	mRNA and Viral-Vector based
Lim et al. (2021)[40]	Singapore	Cross-Sectional	Range: 18–76 Median: 35	1340 F, 364 M	Early: 196 (anaphylaxis = 0); 46: itch/rash,16: numbness. Late: Dose 1: 975: Injection site reaction(rash, redness, swelling, pain), 3: Swelling of the eyes, lips, or face,42: Skin reaction, not at the injection site (rash, hives, urticaria, itch); Dose 2: 1195: Injection site reaction (rash, redness, swelling, pain),13: Swelling of the eyes, lips or face,90:Skin reaction, not at the injection site (rash, hives, urticaria, itch)		Not specified

TABLE 1 (Continued)

Study	Country	Design	Sample age (Mean ± SD/range) (years)	Sample sex	Number of cases with cutaneous manifestations	Cutaneous manifestation type	Vaccine type
Magro et al. (2021)[32]	USA	Unknown	Not specified	Not specified	22	Suprapubic erythema and swelling; generalized erythema and pustules; generalized pruritic rash; fixed urticarial and purpuric papular rash; diffuse macular morbilliform rash, generalized erythematous papulovesicular eruption; purpura with hives; purple acral nodules; itchy red papules; urticarial plaques; widespread itchy papules with blisters; eczematous rash; eczematous dermatitis; papulovesicular rash; vesicular pustular rash; red spots all over the body; eczematous reaction turning developing into nummular plaques; petechial macules and blanching macules and papules	Not specified
McMahon et al. (2021)[22]	USA and Germany	Cross-Sectional	Not specified	Not specified	414	Delayed large local reaction, Local injection site reaction(Swelling, Erythema, Pain), Urticaria within and after 24 h and with unknown timing, Morbilliform, Erythromelalgia, Vesicular, Pernio/chilblains, Angioedema, Pityriasis rosea, Erythema multiforme, Filler reaction, Vasculitis, Contact dermatitis, Reaction in a breastfed infant, Onset of new dermatologic condition, Petechiae, full-body skin pain/burning, hypopigmentation, Sweet's-like fixed urticarial plaque, pseudovesiculated patches, spongiotic dermatitis, canker sore on tongue, aphthous ulceration on labium, monomorphic papular eruption, eczematous pigmented purpura, spongiotic dermatitis	mRNA
McMahon et al. (2021)[23]	USA and Germany	Cross-Sectional	Not specified	Not specified	803 (58 included for pathology)	Vaccine-related eruption of papules and plaques (V-REPP) ($n = 15$), bullous pemphigoid-like ($n = 12$), dermal hypersensitivity reactions ($n = 4$), herpes zoster ($n = 4$), lichen planus-like ($n = 4$), pernio ($n = 3$), urticaria ($n = 2$), neutrophilic dermatosis ($n = 2$), leukocytoclastic vasculitis ($n = 2$), morbilliform ($n = 2$), delayed large local reactions ($n = 2$), erythromelalgia ($n = 1$), and other ($n = 5$), including Stevens–Johnson syndrome ($n = 1$) and erythema multiforme ($n = 1$).	mRNA and Viral-Vector based

(Continues)

TABLE 1 (Continued)

Study	Country	Design	Sample age (Mean ± SD/ range) (years)	Sample sex	Number of cases with cutaneous manifestations	Cutaneous manifestation type	Vaccine type
Menni et al. (2021)[41]	UK	Prospective Cohort	50.6 ± 19.2	F: 373135 M: 254248	Pfizer: 1st dose: Pain (61016), Swelling (13264), Tenderness (119431), Itch (6242), Redness (7891), Warmth (14024), Bruising (1872); Allergic: Rash (682), Skin burning (2075), Red welts on face and lips (469); 2nd dose: Pain (4515), Swelling (1285), Tenderness (6705), Itch (840), Redness (953), Warmth (1245), Bruising (64); Allergic: Rash (103), Skin burning (324), Red welts on face and lips (59). AstraZeneca: 1st dose: Pain (33939), Swelling (9769), Tenderness (87609), Itch (6934), Redness (7431), Warmth (14033), Bruising (4269); Allergic: Rash (1432), Skin burning (5940), Red welts on face and lips (846)		mRNA and Viral-Vector based
Niebel et al. (2021)[24]	Germany	Cross-Sectional	Not specified	Not specified	19	Erythematous Plaques (Generalized or Trunk), Periorbital erythema and edema, V-sign, Eczematous Plaques(Generalized or Localized), Grouped pruritic papulovesicular, Petechial Plaques, Generalized Hives, Generalized scaling plaques, Extremities Erythema, Generalized Exanthema, Pale erythematous maculae along Langer lines, Pityriasis Rosea	mRNA and Viral-Vector based
Patel et al. (2021)[42]	USA	Retrospective Cohort	Not specified	Not specified	77	Erythema, Swelling, Other	mRNA
Polack et al. (2020)[43]	Multinational	Prospective Cohort	Range: 16–89	F: 9221 M: 9639	Dose 1: 177 Dose 2: 170	Pain, Redness, Swelling,	Not specified
Pourani et al. (2021)[25]	Iran	Cross-Sectional	28.08 ± 11.94	Not specified	228	focal injection site reaction (induration in 138 [18.1%] and erythema in 102 [13.4%] individuals), exanthematous rash ($n = 29$, 3.8%), urticaria ($n = 25$, 3.3%), petechiae/purpura ($n = 16$, 2.1%), vesicular eruption ($n = 8$, 1.1%), pernio-like lesions ($n = 8$, 1.1%), angioedema ($n = 5$, 0.7%), erythema multiforme-like eruption ($n = 2$, 0.3%), and zoster ($n = 2$, 0.3%)	Viral-Vector based and Inactivated
Riad et al. (2021)[26]	Slovakia	Cross-Sectional	37.77 ± 11.61	F: 402 M: 120	18	Injection Site Pain, Injection Site Swelling, Injection Site Redness, Cutaneous Total: Rash, Angioedema	mRNA
Riad et al. (2021)[27]	Czech Republic	Cross-Sectional	42.56 ± 10.5	F: 776 M: 100	45	Injection site pain, Injection Site swelling, Injection site redness; Rash, Urticaria & Other non-specific conditions	mRNA
Riad et al. (2021)[28]	Czech Republic	Cross-Sectional	22.86 ± 2.05	F: 378 M: 158 3 Preferred not to say	498	Pain 495, Swelling 94, Redness 72, Skin rash 2, Skin eruption 2	mRNA

TABLE 1 (Continued)

Study	Country	Design	Sample age (Mean ± SD/ range) (years)	Sample sex	Number of cases with cutaneous manifestations	Cutaneous manifestation type	Vaccine type
Riad et al. (2021)[29]	The Czech Republic and Germany	Cross-Sectional	35.37 ± 12.62	F: 71 M: 21	4	Injection Site Pain, Swelling, and Redness; Skin Rash	Viral-Vector based
Shavit et al. (2021)[44]	Israel	Prospective Cohort	52 ± 16	Not specified	Local: 164 Non-local: 32	Injection site pain; skin eruption, itching, or urticaria	mRNA
Vanegas et al. (2021)[30]	Ecuador	Cross-Sectional	39.3 ± 13.5	F: 50.4% M: 41.6%	1st dose: Pain 883, Erythema 71, Edema 103, Pruritus 8, Generalized rash 10, Generalized pruritus 8, Petechiae 3, Dermatitis 0, Eczema 1, Idiopathic urticaria 1, Facial rash 1; 2nd dose: Pain 718, Erythema 139, Edema 165, Pruritus 16, Generalized rash 4, Generalized pruritus 8, Petechiae 4, Dermatitis 1, Eczema 2, Idiopathic urticaria 0, Facial rash 0		mRNA
Wang et al. (2021)[45]	China	Cohort	Not specified	Not specified	93 local pain, two local Induration, 6 Skin itching, 2 Local rash		Inactivated
Zavala-Flores et al. (2021)[31]	Peru	Cross-Sectional	38.9	F: 94%	Arm Pain [41% mild pain, 33% Moderate Pain, 13% Severe Pain]		mRNA

vaccines 39% and 31% more susceptible to developing the mentioned types of lesions, respectively (Figures 4 and 5).

The heterogeneities between the studies in all three analyses on the non-local side effects were negligible ($I^2 = 0\%$; χ^2 *p*-values of 0.6, 0.98, and 0.38, respectively), while the publication biases were also statistically insignificant (*p*-values of 0.9389, 0.8630, and 0.5613, respectively).

4 | DISCUSSION

COVID-19 vaccinations offer excellent protection from a significant illness, hospitalization, and death. Moreover, there is evidence that getting vaccinated reduces the chances of spreading the virus; therefore, the decision to receive the vaccine could protect others. COVID-19 vaccine-induced cutaneous reactions have been reported, but they are not well understood. Given the importance of widespread vaccination in containing the pandemic, we sought to gather information on cutaneous side effects to map out the global landscape of COVID-19 vaccine-related dermatologic side effects.

A total of 36 studies were included in our systematic review. Discomfort, erythema, and swelling were the most common local side effects, while rashes, urticaria, and angioedema were the most common non-local side effects. Patients also reported flare-ups of their underlying disorders or the onset of new diseases of various etiologies in a few cases. Most of these cases were only followed until the lesions subsided. However, in cases where more severe pathologies were suspected (e.g., Steven–Johnson Syndrome), the patient was hospitalized and received the required therapeutic regimen, which, based on the reports from the relevant studies, was similar to the routine and standard clinical practice (e.g., immunosuppressant therapy with either corticosteroids or immunomodulators).

We also discovered in our meta-analyses that, while viral vector-based vaccines are slightly safer when injection site complaints are of concern, people who received mRNA vaccines had much fewer non-local cutaneous adverse events. We also found that even though viral vector-based vaccines demonstrated a lower frequency of reactions at the injection site, the mRNA vaccines were significantly less culpable in the unfortunate experience of non-local adverse reactions in those who received them. Moreover, conclusions regarding local cutaneous reactions cannot be confidently withdrawn due to their high heterogeneity and bias. However, the results from the analysis of non-local reactions are quite the opposite in this regard.

There are some limitations to our systematic review and meta-analysis. It was practically impossible to set a group of individuals aside as the control group for the presumably intended comparisons. Furthermore, a brand-by-brand vaccine safety assessment could not be achieved. In addition, the chronology of the events was not stated in most of the included studies, which added to the subjective reporting of injection site complaints and could cloud the scientific judgment

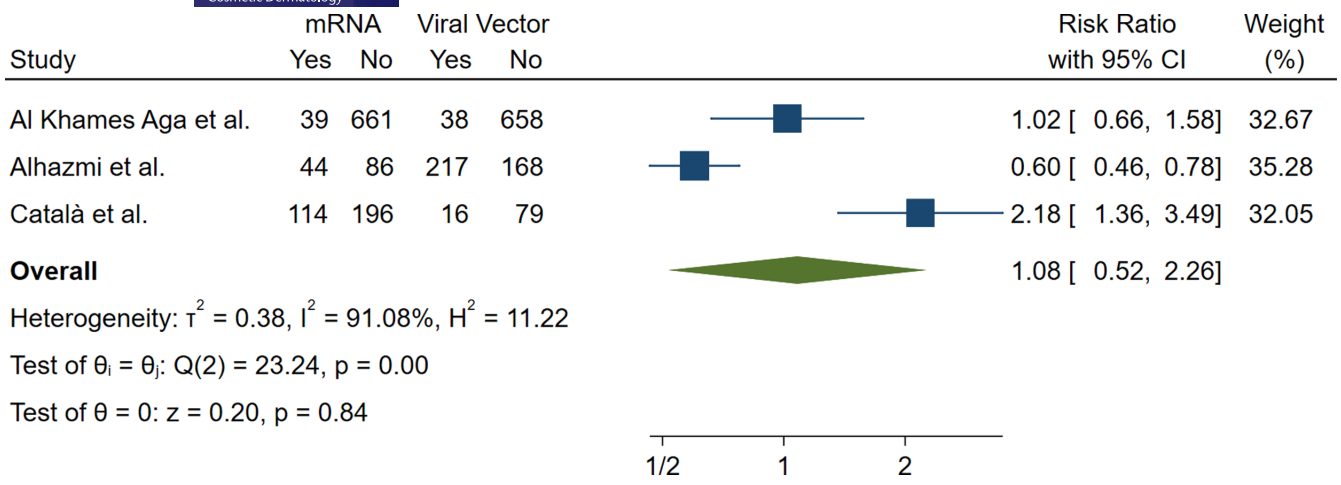

FIGURE 2 The meta-analysis of the frequency of local reactions comparing mRNA and Viral vector-based vaccines

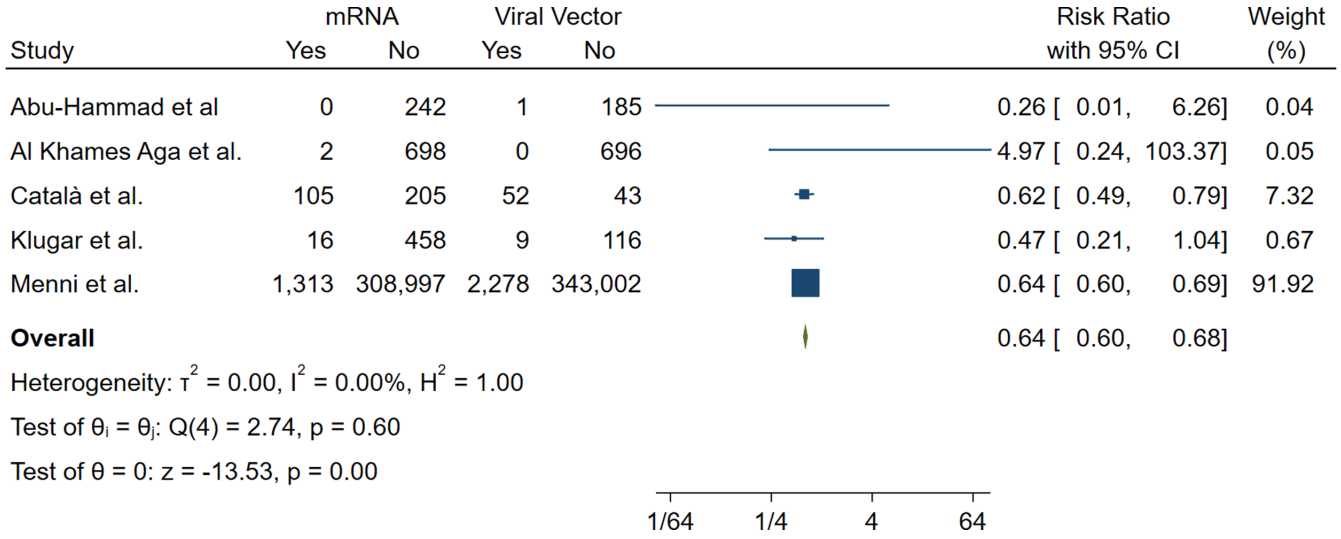

FIGURE 3 The meta-analysis of the frequency of non-local reactions comparing mRNA and Viral vector-based vaccines

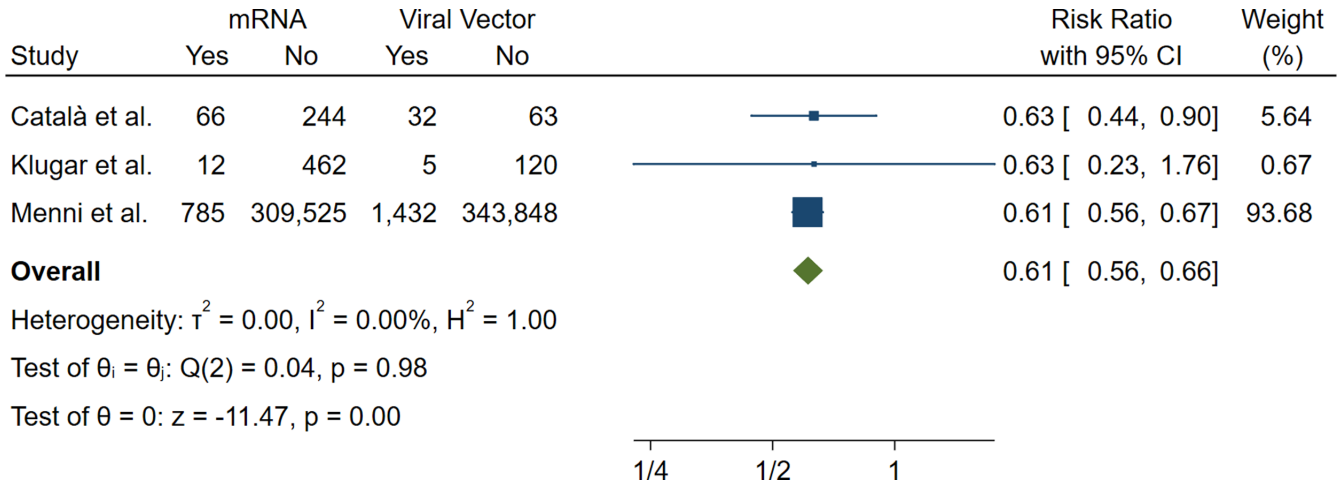

FIGURE 4 The meta-analysis of the frequency of rashes, in general, comparing mRNA and Viral vector-based vaccines

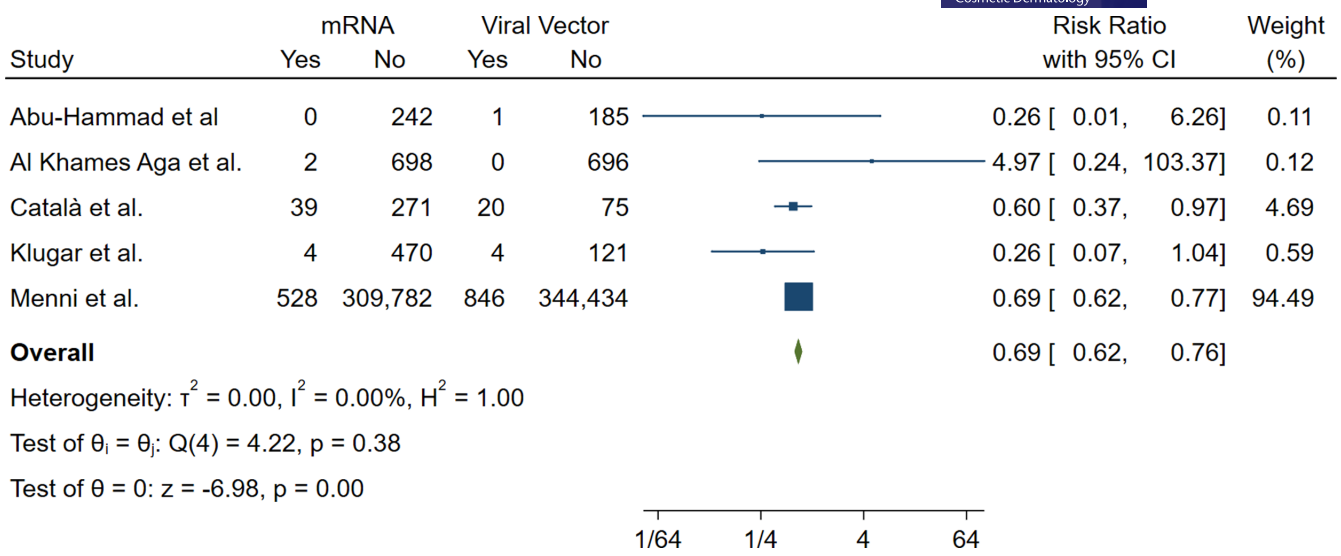

FIGURE 5 The meta-analysis of the frequency of urticarial-angioedema lesions comparing mRNA and Viral vector-based vaccines

on the issue. Only in a few studies, the pathophysiology of the cutaneous reactions was thoroughly investigated. For instance, according to the studies reviewed in this systematic review, the new development of the previously not seen lesions can be traced back to either a vaccine-related delayed hypersensitivity reaction or T-cell-mediated reaction raising from a viral molecular similarity to the cells of the skin.[23,24] However, in a high proportion of the individuals experiencing non-local reactions, the pathophysiology or mechanism of such incidents was not thoroughly investigated in the included studies, usually due to their mostly self-limited nature. Therefore, we cannot rule out the occurrence of improper lesion characterization. Furthermore, several studies had less than anticipated methodological quality.

Finally, cutaneous reactions to the COVID-19 vaccine are similar to common cutaneous drug eruptions and COVID-19 cutaneous manifestations. The dermatology perspective on the COVID-19 mass vaccination campaign is multifaceted and critical in motivating clinicians to address cutaneous vaccination reactions and reassure patients adequately. Further high-quality research is needed to assess better how and why cutaneous reactions occur in different vaccines. Physicians should also consider numerous comorbid disorders associated with reactions to COVID-19 immunization to provide the optimal evaluation and therapy. Moreover, the final goal is to reassure concerned individuals about the novel COVID-19 vaccines' overall attractive safety profiles, one of which is their dermatologic standpoint.

AUTHOR CONTRIBUTIONS

All authors participated in designing the protocol. First, all authors participated in the design of the study. MJ and MS then did the literature search. MS, MJ, and NS selected the studies and extracted the relevant information, then assessed and confirmed by the senior author. All authors then participated in synthesizing the data. MS, ZA, MJ, and NA also wrote the first draft of the paper. NA provided critical guidance on the analysis and overall direction of the study. MS performed the meta-analysis. All authors critically revised successive drafts of the paper and approved the final version.

CONFLICT OF INTEREST

The authors declare that no conflict of or competing interests existed or occurred in the conduction of this manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICAL APPROVAL

No ethical approval was required as this manuscript is a review article with no original research data.

ORCID

Mohammad Shafie'ei https://orcid.org/0000-0001-7319-000X
Marzieh Jamali https://orcid.org/0000-0002-6241-4108
Zahra Akbari https://orcid.org/0000-0002-3315-8977
Nastaran Sarvipour https://orcid.org/0000-0002-9040-8899
Mohadese Ahmadzade https://orcid.org/0000-0001-7184-0275
Najmeh Ahramiyanpour https://orcid.org/0000-0003-3171-5933

REFERENCES

1. Allergic reactions including anaphylaxis after receipt of the first dose of Pfizer-BioNTech COVID-19 vaccine — United States, December 14–23, 2020. *Morb Mortality Wkly Rep*. 2021;70(2):46-51. doi:10.15585/mmwr.mm7002e1
2. Coronavirus disease (COVID-19): vaccines. https://www.who.int/news-room/questions-and-answers/item/coronavirus-disease-(covid-19)-vaccines?gclid=Cj0KCQiAoY-PBhCNARIsABcz771VYmFy9gPcxdbOY_bbUHGDi9XpocmxYi6DXWdvUctWde3QmJq8-LcaAvh2EALw_wcB&topicsurvey=v8kj13
3. Baden LR, El Sahly HM, Essink B, et al. Efficacy and safety of the mRNA-1273 SARS-CoV-2 vaccine. *N Engl J Med*. 2021;384(5):403-416.
4. Polack FP, Thomas SJ, Kitchin N, et al. Safety and efficacy of the BNT162b2 mRNA Covid-19 vaccine. *N Engl J Med*. 2020;383:2603-2615.
5. COVID-19 vaccine tracker and landscape. https://www.who.int/publications/m/item/draft-landscape-of-covid-19-candidate-vaccines

6. Kaiyu RT, Regulatory Affairs Professionals Society. *Handbook of Medical Device Regulatory Affairs in Asia*. Jenny Stanford Publishing; 2013:225-232.
7. Xia S, Zhang Y, Wang Y, et al. Safety and immunogenicity of an inactivated SARS-CoV-2 vaccine, BBIBP-CorV: a randomised, double-blind, placebo-controlled, phase 1/2 trial. *Lancet Infect Dis*. 2021;21(1):39-51.
8. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71.
9. Morgan RL, Whaley P, Thayer KA, Schünemann HJ. Identifying the PECO: a framework for formulating good questions to explore the association of environmental and other exposures with health outcomes. *Environ Int*. 2018;121(Pt 1):1027-1031. doi:10.1016/j.envint.2018.07.015
10. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. *Syst Rev*. 2016;5(1):1-10.
11. Abu-Hammad O, Alduraidi H, Abu-Hammad S, et al. Side effects reported by jordanian healthcare workers who received covid-19 vaccines. *Vaccine*. 2021;9(6):577.
12. Al Bahrani S, Albarrak A, Alghamdi OA, et al. Safety and reactogenicity of the ChAdOx1 (AZD1222) COVID-19 vaccine in Saudi Arabia. *Int J Infect Dis*. 2021;110:359-362.
13. Al Khames Aga QA, Alkhaffaf WH, Hatem TH, et al. Safety of COVID-19 vaccines. *J Med Virol*. 2021;93(12):6588-6594.
14. Alhazmi A, Alamer E, Daws D, et al. Evaluation of side effects associated with covid-19 vaccines in Saudi Arabia. *Vaccine*. 2021;9(6):674.
15. Català A, Muñoz-Santos C, Galván-Casas C, et al. Cutaneous reactions after SARS-CoV-2 vaccination: a cross-sectional Spanish nationwide study of 405 cases. *Br J Dermatol*. 2022;186(1):142-152.
16. Choi YY, Kim MK, Kwon HC, Kim GH. Safety monitoring after the BNT162b2 COVID-19 vaccine among adults aged 75 years or older. *J Korean Med Sci*. 2021;36(45):e318.
17. Cuschieri S, Borg M, Agius S, Souness J, Brincat A, Grech V. Adverse reactions to Pfizer-BioNTech vaccination of healthcare workers at Malta's state hospital. *Int J Clin Pract*. 2021;75(10):e14605.
18. Elnaem MH, Mohd Taufek NH, Ab Rahman NS, et al. Covid-19 vaccination attitudes, perceptions, and side effect experiences in Malaysia: do age, gender, and vaccine type matter? *Vaccine*. 2021;9(10):1156.
19. Jęśkowiak I, Wiatrak B, Grosman-Dziewiszek P, Szeląg A. The incidence and severity of post-vaccination reactions after vaccination against covid-19. *Vaccine*. 2021;9(5):502.
20. Kadali RAK, Janagama R, Peruru S, Malayala SV. Side effects of BNT162b2 mRNA COVID-19 vaccine: a randomized, cross-sectional study with detailed self-reported symptoms from healthcare workers. *Int J Infect Dis*. 2021;2021(106):376-381.
21. Klugar M, Riad A, Mekhemar M, et al. Side effects of mRNA-based and viral vector-based COVID-19 vaccines among German healthcare workers. *Biology (Basel)*. 2021;10(8):752.
22. McMahon DE, Amerson E, Rosenbach M, et al. Cutaneous reactions reported after Moderna and Pfizer COVID-19 vaccination: a registry-based study of 414 cases. *J Am Acad Dermatol*. 2021;85(1):46-55.
23. McMahon DE, Kovarik CL, Damsky W, et al. Clinical and pathologic correlation of cutaneous COVID-19 vaccine reactions including V-REPP: a registry-based study. *J Am Acad Dermatol*. 2022;86(1):113-121.
24. Niebel D, Wenzel J, Wilsmann-Theis D, Ziob J, Wilhelmi J, Braegelmann C. Single-center Clinico-pathological case study of 19 patients with cutaneous adverse reactions following COVID-19 vaccines. *Dermatopathology (Basel)*. 2021;8(4):463-476.
25. Pourani MR, Shahidi Dadras M, Salari M, Diab R, Namazi N, Abdollahimajd F. Cutaneous adverse events related to COVID-19 vaccines: a cross-sectional questionnaire-based study of 867 patients. *Dermatol Ther*. 2022;35(2):e15223.
26. Riad A, Hocková B, Kantorová L, et al. Side effects of mRNA-based COVID-19 vaccine: Nationwide phase IV study among healthcare Workers in Slovakia. *Pharmaceuticals (Basel)*. 2021;14(9):873.
27. Riad A, Pokorná A, Attia S, Klugarová J, Koščík M, Klugar M. Prevalence of COVID-19 vaccine side effects among healthcare Workers in The Czech Republic. *J Clin Med*. 2021;10(7):1428.
28. Riad A, Pokorná A, Klugarová J, et al. Side effects of mrna-based covid-19 vaccines among young adults (18–30 years old): an independent post-marketing study. *Pharmaceuticals*. 2021;14(10):1049.
29. Riad A, Pokorná A, Mekhemar M, et al. Safety of ChAdOx1 nCoV-19 vaccine: independent evidence from two EU states. *Vaccines (Basel)*. 2021;9(6):673.
30. Vanegas E, Robles-Velasco K, Osorio MF, et al. Adverse reactions following COVID-19 vaccination: an Ecuadorian experience. *Ann Med Surg*. 2021;72:103044.
31. Zavala-Flores E, Salcedo-Matienzo J, Quiroz-Alva A, Berrocal-Kasay A. Side effects and flares risk after SARS-CoV-2 vaccination in patients with systemic lupus erythematosus. *Clin Rheumatol*. 2022;41(5):1349-1357.
32. Magro C, Crowson AN, Franks L, Rouhani PS, Whelan P, Nuovo G. The histologic and molecular correlates of COVID-19 vaccine-induced changes in the skin. *Clin Dermatol*. 2021;2021:966-984.
33. Amer M, Altaf S, Azhar A. The safety of verocell covid-19 (Sinopharm) vaccination among health care workers in khyber teaching hospital, Peshawar. *Journal of Medical Sciences (Peshawar)*. 2021;29(3):99-103.
34. Cugno M, Consonni D, Lombardi A, et al. Increased risk of urticaria/angioedema after BNT162b2 mRNA COVID-19 vaccine in health care workers taking ACE inhibitors. *Vaccines (Basel)*. 2021;9(9):1011.
35. Golan Y, Prahl M, Cassidy AG, et al. COVID-19 mRNA vaccination in lactation: assessment of adverse events and vaccine related antibodies in mother-infant dyads. *Front Immunol*. 2021;12:777103.
36. Grieco T, Maddalena P, Sernicola A, et al. Cutaneous adverse reactions after COVID-19 vaccines in a cohort of 2740 Italian subjects: an observational study. *Dermatol Ther*. 2021;34(6):e15153.
37. Im JH, Kim E, Lee E, et al. Adverse events with the Pfizer-BioNTech COVID-19 vaccine among Korean healthcare workers. *Yonsei Med J*. 2021;62(12):1162-1168.
38. Jeon M, Kim J, Oh CE, Lee JY. Adverse events following immunization associated with the first and second doses of the chadox1 ncov-19 vaccine among healthcare workers in Korea. *Vaccine*. 2021;9(10):1096.
39. Kaplan B, Farzan S, Coscia G, et al. Allergic reactions to coronavirus disease 2019 vaccines and addressing vaccine hesitancy: Northwell health experience. *Ann Allergy Asthma Immunol*. 2022;128(2):161-168.e1.
40. Lim SM, Chan HC, Santosa A, Quek SC, Liu EHC, Somani J. Safety and side effect profile of Pfizer-BioNTech COVID-19 vaccination among healthcare workers: a tertiary hospital experience in Singapore. *Ann Acad Med Singap*. 2021;50(9):703-711.
41. Menni C, Klaser K, May A, et al. Vaccine side-effects and SARS-CoV-2 infection after vaccination in users of the COVID symptom study app in the UK: a prospective observational study. *Lancet Infect Dis*. 2021;21(7):939-949.
42. Patel GB, Chhiba KD, Chen MM, et al. COVID-19 vaccine-related presumed allergic reactions and second dose administration by using a two-step graded protocol. *Allergy Asthma Proc*. 2021;42(6):515-521.
43. Polack FP, Thomas SJ, Kitchin N, et al. Safety and efficacy of the BNT162b2 mRNA Covid-19 vaccine. *N Engl J Med*. 2020;383(27):2603-2615.
44. Shavit R, Maoz-Segal R, Iancovici-Kidon M, et al. Prevalence of allergic reactions after Pfizer-BioNTech COVID-19 vaccination among adults with high allergy risk. *JAMA Netw Open*. 2021;4(8):e2122255.
45. Wang GF, Zhu L, Zhu YQ, et al. Safety survey by clinical pharmacists on COVID-19 vaccination from a single center in China. *Hum Vaccines Immunother*. 2021;17(9):2863-2867.
46. Burl OM, Herzum A, Micalizzi C, Cozzani E, Parodi A. Cutaneous reactions to COVID-19 vaccine at the dermatology primary care. *Immun Inflamm Dis*. 2022;10(2):265-271.

47. Lindgren AL, Austin AH, Welsh KM. COVID arm: delayed hypersensitivity reactions to SARS-CoV-2 vaccines misdiagnosed as cellulitis. *J Prim Care Community Health*. 2021;12:21501327211024431. doi:10.1177/21501327211024431

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Shafie'ei M, Jamali M, Akbari Z, Sarvipour N, Ahmadzade M, Ahramiyanpour N. Cutaneous adverse reactions following COVID-19 vaccinations: A systematic review and meta-analysis. *J Cosmet Dermatol*. 2022;00:1-15. doi: 10.1111/jocd.15261