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The prevalence and risk factors of facial pressure injuries related to adult non-invasive ventilation equipment: A systematic review and meta-analysis

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Abstract

To systematically assess the prevalence of facial pressure injuries related to adult non-invasive ventilation equipment, and risk factors of facial pressure injuries. PubMed, Cochrane Library, Web of Science, Embase, China Knowledge Resource Integrated Database, Wanfang Database, Chinese Biomedical Database and Weipu Database were comprehensively searched for observational studies investigating the prevalence and risk factors of facial pressure injuries related to adult non-invasive ventilation equipment from inception to May 16th, 2022. Filter articles based on inclusion and exclusion criteria. The quality of the included studies was evaluated independently by two investigators. Meta-analysis was conducted using Stata 16.0 software package. In total, 2835 articles were screened and data from 12 studies were used in meta-analysis. The prevalence of facial pressure injuries related to adult non-invasive ventilation equipment was 25% (95% confidence interval, CI:15% to 37%, $I^2 = 97.34\%$, $P < 0.0001$). After controlling for confounding variables, the following risk factors of facial pressure injuries: use equipment form, with diabetes, fever, cumulative time of using equipment, facial skin oedema and Glasgow score. Understanding the risk factors of facial pressure injuries can provide the healthcare personnel with the theoretical basis for the management and treatment of the patients.

KEYWORDS

noninvasive ventilation, pressure ulcer, prevalence, risk factors, systematic review

Yuting Wei and Juhong Pei contributed equally to this work.

Key Messages

- despite the facts that the prevalence and risk factors of facial pressure injuries related to adult non-invasive ventilation equipment are widely reported, these results have not been synthesised
- a meta-analysis was to systematically assess the prevalence of facial pressure injuries related to adult non-invasive ventilation equipment, and risk factors of facial pressure injuries
- the prevalence of facial pressure injuries related to adult non-invasive ventilation equipment was 25%
- use equipment form, with diabetes, fever, cumulative time of using equipment, facial skin oedema and Glasgow score were identified as risk factors of facial pressure injuries related to adult non-invasive ventilation equipment

1 | INTRODUCTION

Medical device-related pressure injury (MDRPI) was[1,2] defined as "a description of the etiology that results from the use of a diagnostic or therapeutic related device, the appearance of which is consistent with the style or shape of the medical device." Such lesions should be staged using the NPIAP staging system. Non-invasive ventilation equipment, as a respiratory assistance therapy technology for the treatment of patients with acute and chronic respiratory failure,[3-5] can effectively improve the lung ventilation, relieve respiratory muscle fatigue and correct respiratory failure.[6] Multiple studies[7,8] have shown that non-invasive ventilation is a common cause of MDRPI.

Research has shown patients who use non-invasive ventilation equipment need to wear an oronasal mask or nasal mask for a long time, facial pressure injuries develop on bony prominence regions due to contact pressure between the interface and the patient's skin.[9,10] Therefore, facial pressure injuries is a common complication during the use of non-invasive ventilation equipment.[11] It will cause severe pain, ulcers, or bleeding,[12] at the same time, damage to the local skin may further induce infection or even aggravate the condition, which is not conducive to disease recovery,[13] even lead to ventilation equipment intolerance, increased patient suffering and medical costs.[14]

At present, due to the different sample sizes and the fact that there are few large-scale epidemiological investigations on facial pressure injury related to adult non-invasive ventilation equipment at home and abroad, most of them are limited to a single city or country, reporting the current situation of facial pressure injury in a single institution. In addition to this, the estimated prevalence of facial pressure injury related to adult non-invasive ventilation equipment ranges from 3.9%[15] to 100%.[16] Therefore, the prevalence of facial pressure injuries related to adult non-invasive ventilation equipment has been reported differently in different studies. This has made it difficult to understand the epidemiology of facial pressure injures associated with non-invasive ventilation equipment. However, facial pressure injuries can be avoided and reduced, the study[17] shows identifying risk factors that correlate with non-invasive ventilation equipment related pressure injuries can direct procedures to prevent pressure injury in patients at high risk. Therefore, having a detailed understanding of the prevalence and risk factors of facial pressure injuries related to adult non-invasive ventilation equipment is great significance for the prevention and control of facial pressure injuries.

Recently, a systematic review and meta-analysis of medical device-related pressure ulcers was published by Debra Jackson.[18] Although facial pressure injuries related to adult non-invasive ventilation equipment is a type of MDRPI, the current study has not reported. The aim of this systematic review and meta-analysis is two-fold: 1. to systematically assess the prevalence of facial pressure injuries related to adult non-invasive ventilation equipment, including stratification by pressure ulcer site, gender, countries, stages of pressure injuries and 2. to identify risk factors for facial pressure injury, provide evidence support for pressure injury prevention and better pressure injury management practices for healthcare workers.

2 | METHODS

2.1 | Protocol registration

The present meta–analytic review was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta–Analyses (PRISMA) guidelines.[19] A detailed study protocol is available on the PROSPERO website under the registration number CRD42022302332.

2.2 | Search strategy

A comprehensive search of the literature was performed using eight electronic databases. PubMed, the Cochrane Library, Web of Science, Embase, China Knowledge Resource Integrated Database (CNKI), Wanfang Database, Chinese Biomedical Database (CBM) and Weipu Database (VIP)were searched from the oldest publications available in each of the databases through May 16th, 2022. The search strategies were performed through a combination of Mesh terms and free words. The following Mesh terms and free words were used: "mechanical ventilation", "artificial ventilation", "assisted ventilation", "artificial respiration", "positive pressure ventilation", "respirator*", "pulmonary ventilat*", "non invasive ventilation", "noninvasive ventilation", "non-invasive ventilation", "positive airway pressure", "positive pressure respiration", "pressure support ventilation", "mask ventilation", "bipap", "nippv", "nppv", "niv", "cpap", "niav", "aprv", "ippb", "ippv", "peep", "positive expiratory pressure", "pressure ulcer", "pressure ulcer*", "pressure injur*", "pressure sore*", "pressure damage", "decubitus ulcer", "bed ulcer", "bed sore", "bedsore", "skin injury". The study did not require the approval of an Ethics Committee, since it is based entirely on previously published studies.

2.3 | Study selection

The criteria for inclusion of a study in the systematic review were as follows:

(1) adults using non-invasive ventilation equipment, (2) the studies had to be observational, (3) studies that reported all stages of facial pressure injury related to adult non-invasive ventilation equipment, (4) prevalence and/or risk factors of facial pressure injuries related to adult non-invasive ventilation equipment. The exclusion criteria were as follows: (1) studies contained incomplete data, (2) the language of the publication was other than English or Chinese.

Endnote X9 software were used to remove duplicates and to facilitate the screening process. All titles and abstracts were screened for inclusion/exclusion based on eligibility criteria. When potentially eligible studies could not be determined by abstract alone, full texts were examined by further assessment.

2.4 | Data extraction

Data were extracted from the included studies by two independent (YT wei and JH pei) investigators. The following information was recorded: first author name, publication year, study location, sample size, diagnostic criteria, the prevalence of facial pressure injuries related

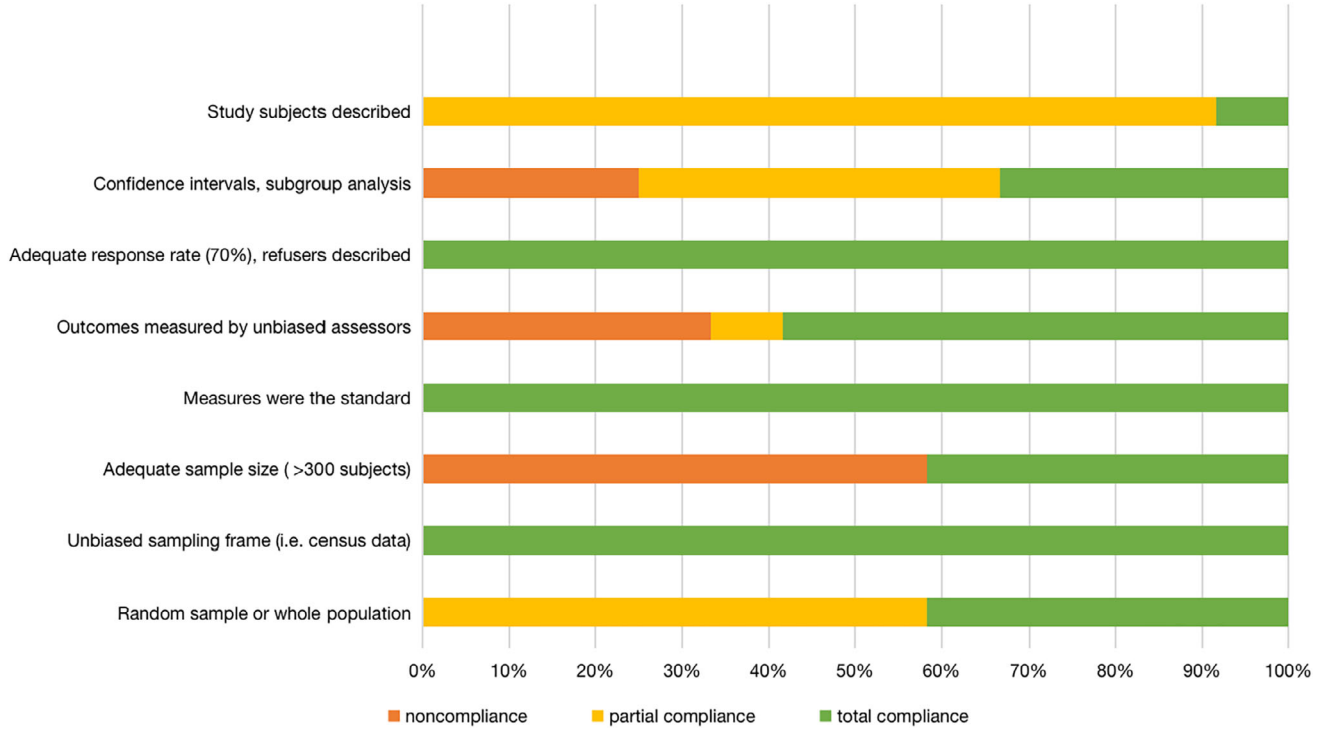

FIGURE 1 Critical appraisal of studies

to adult non-invasive ventilation equipment, and stated risk factors. All extracted data were stored in the Microsoft Excel file format.

2.5 | Quality appraisal

The quality of included studies was assessed independently by two investigators using the Disease Epidemic Quality Tool developed by Loney et al,[20] and any disagreements regarding study quality were resolved by a third investigator. The total score of the evaluation item is 8 points. Every item ever 1 point for full compliance, 0 for non-compliance or partial compliance. Higher cumulative scores indicate less risk of bias in the study. As shown in Figure 1, the greener each criterion is, the lower the risk of bias in the study.

2.6 | Data analysis

For analysis, the data were performed with stata16.0 software. The outcome indicators of each study were tested for heterogeneity with Cochrane's Q statistic, I^2 values of 25%, 50% and 75% indicate low, moderate and high heterogeneity, respectively. Pooled prevalence and 95% confidence intervals (CIs) for facial pressure injuries were calculated using a random-effects model when the Cochrane's Q statistic detected significant heterogeneity, otherwise, a fixed-effects model was used. $P < 0.05$ was the threshold for statistical significance. The prevalence results are shown in a forest plot. The proportions of participants diagnosed with facial pressure injuries were extracted from all included studies in order to calculate the pooled prevalence of this condition. To assess the risk factors of facial pressure injuries, the odds ratios (ORs) and associated 95% CIs were extracted from included studies, and all eligible available data were summarised. Publication bias was identified by using funnel plot and the asymmetry was tested by using Egger's linear regression method. ($P < 0.1$ is considered as significant).

In stratified meta-analyses, the literature data were divided into subgroups according to the pressure ulcer site, gender, countries, stages of pressure injuries. Pooled

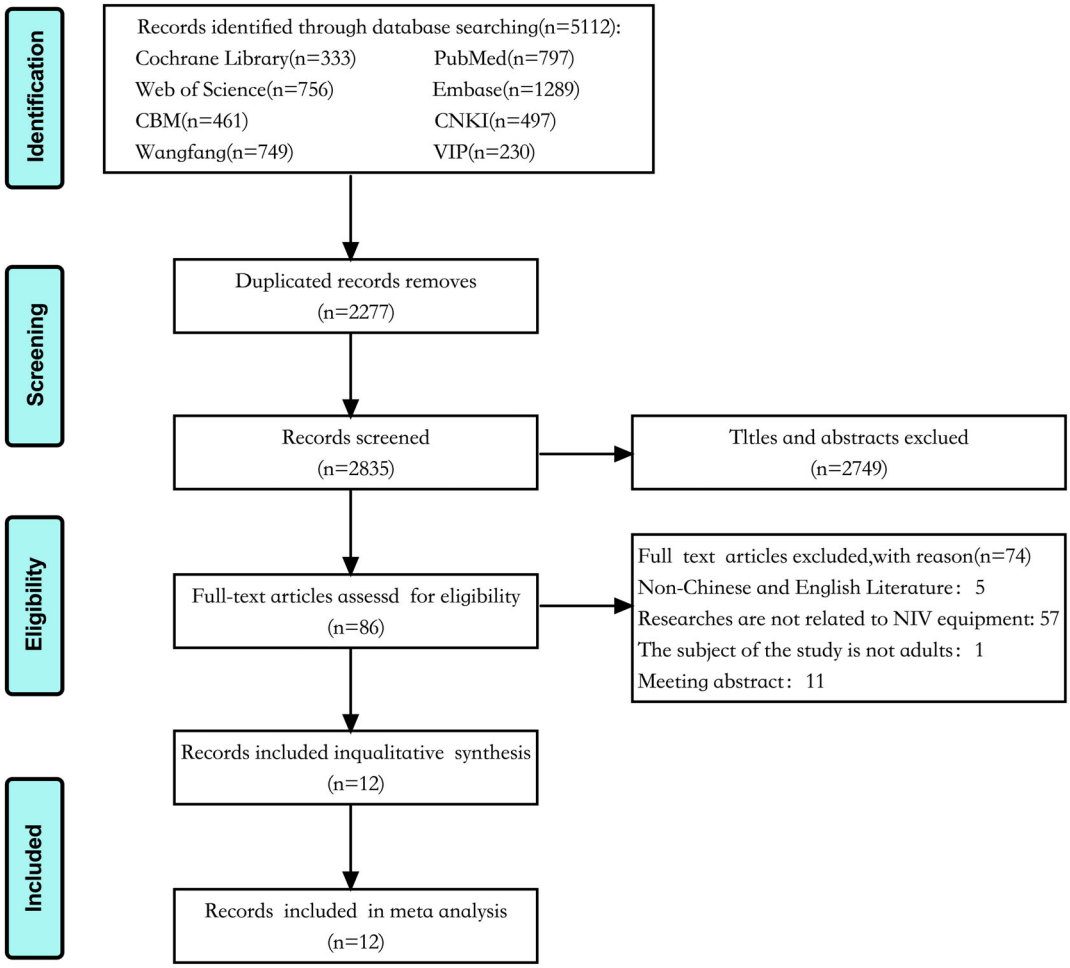

FIGURE 2 Flow diagram of study selection in the meta-analysis

TABLE 1 Characteristics of the include studies

Authors (year)	Country	Study design	Sample size (N)	% of Males	Prevalence	Pressure ulcer site (N)	Stages of pressure injuries (N)	Risk factors assessed	Quality appraisal
He et al. (2020)[10]	China	cross-sectional	189(10)	64.0%	5.29%	nose wings (5), cheek (2)	/	age, use equipment form, hot and humid facial skin, with diabetes, forced position	4
Zeng et al. (2013)[21]	China	cross-sectional	44(13)	72.3%	29.54%	/	stage I (6), stage II (7)	Braden score	4
Du et al. (2016)[22]	China	cross-sectional	153(39)	46.4%	25.49%	bridge of nose (20), cheek (5)	stage I (28), stage II (11)	fever, PCO_2, cumulative time of using equipment	4
Shen et al. (2019)[23]	China	cross-sectional	197(38)	50.3%	19.29%	/	/	with diabetes, fever, hypoxia, cumulative time of using equipment, use hormone drugs, serum albumin	4
Deng et al. (2017)[24]	China	case–control	173(48)		27.75%	nose wings (12), bridge of nose (18), cheek (7), forehead (11)	Stage I (17), stage II (30)	age, use equipment form, with chronic diseases, PaO_2, cumulative time of using equipment, use hormone drugs, serum albumin, Glasgow score, SAS score, facial skin oedema, use protective stickers, hypotension, use cardiovascular active substances	5
Chen et al. (2021)[25]	China	cross-sectional	287(56)	38.3%	19.51%	nose wings (15), bridge of nose (27), cheek (4), forehead (10)	/		4
Dang et al. (2021)[26]	China	cross-sectional	32(8)	/	25.00%	/	/	Braden scores, facial skin oedema	7
Viveiros et al. (2019)[15]	Portugal	cross-sectional	103(4)	54.4%	3.88%	/	/		3
Kayser et al. (2018)[27]	US	cross-sectional	804(72)	/	8.96%	/	/		6
Yamaguti et al. (2014)[28]	Brazil	cross-sectional	375(54)	42.7%	14.40%	/	/	cumulative time of using equipment, oronasal mask	4
Erbay et al. (2022)[16]	Turkey.	cohort	17(17)	/	100.00%	bridge of nose (17)	/	age, history of cardiovascular diseases, administration of vasopressors, length of ICU stay, requirement for mechanical ventilation	7
Amini et al. (2022)[29]	Iran	cohort	315(176)	/	55.87%	cheek (21)	/	Braden scale, Glasgow score	7

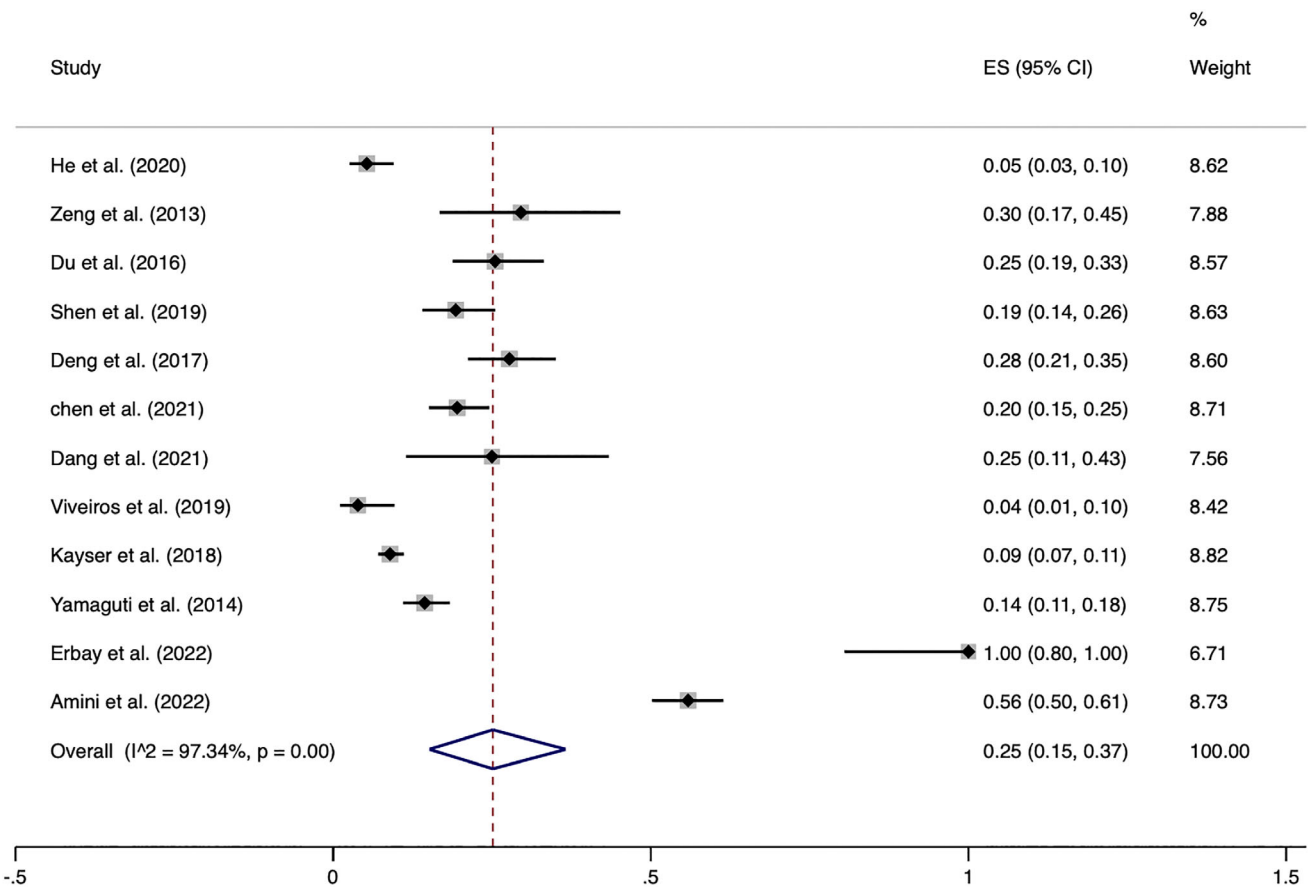

FIGURE 3 Forest plot of prevalence of facial pressure injuries related to adult non-invasive ventilation equipment

TABLE 2 Subgroup analyses by pressure injuries site, gender, countries, stages of pressure injuries

Subgroups	Number of included studies	Prevalence	95%CL-LL	95%CL-UL	I^2	*P* value
Pressure ulcer site						
nose wings	3	5%	3%	7%	47.49%	<0.1
cheek	5	3%	1%	5%	75.26%	<0.1
bridge of nose	4	29%	11%	52%	96.53%	<0.1
forehead	2	4%	3%	7%	0	0.33
Gender						
male	6	8%	4%	14%	86.10%	<0.1
female	6	5%	2%	10%	86.85%	<0.1
Countries						
China	7	20%	13%	28%	88.03%	<0.1
Other	5	33%	12%	59%	98.90%	<0.1
Stages of pressure injuries						
I	3	14%	8%	20%	58.89%	<0.1
II	3	13%	6%	21%	76.30%	<0.1

Note: Pressure injuries were graded using the National Pressure Ulcer Advisory Panel (NPUAP) 2007 edition staging criteria, include: (Suspected) Deep Tissue Injury, stage I, stage II, stage III, stage IV, Unstageable Pressure Ulcers.[30]

estimates of facial pressure injuries prevalence with 95% CIs were then calculated.

3 | RESULTS

3.1 | Study process

Initially retrieved 5112 articles, 797 articles in PubMed, 333 articles in the Cochrane Library, 756 articles in Web of Science, 1289 articles in Embase, 497 articles in CNKI, 749 articles in Wanfang Database, 461 articles in CBM and 230 articles in VIP (Figure 2). The Endnote software was used to exclude duplicate 2277 articles. 2749 articles were excluded from reading titles and abstracts, 74 articles were excluded from reading the full text. Ultimately, a total of 12 studies (6 in Chinese and 6 in English) met the inclusion criteria and were utilised for the meta-analysis.

3.2 | Characteristics of the included studies and methodologic quality

In these 12 included studies that conducted in 4 regions, Asia (n = 9), North America (n = 1), Europe (n = 1) and

TABLE 3 The results of risk factors analysis

No.	Risk factors	Number of included studies	I^2	P (heterogeneity)	Model	OR	LL-UL (95%CI)	*P*-value
1	Age	3	87.6%	<0.01	random	4.06	0.80–20.58	0.09
2	Use equipment form	2	0%	0.55	fixed	4.04	1.60–10.21	0.03
3	With diabetes	2	0%	0.73	fixed	4.16	2.07–8.34	<0.001
4	Braden score	3	94.0%	<0.01	random	0.89	0.32–2.48	0.82
5	Fever	2	0%	0.46	fixed	4.94	2.22–11.00	<0.001
6	Cumulative time of using equipment	4	63.6%	0.04	random	6.64	2.70–16.39	<0.001
7	Use hormone drugs	2	59.7%	0.12	random	2.96	0.89–9.86	0.08
8	Serum albumin	2	76.5%	0.04	random	1.69	0.59–4.87	0.33
9	Facial skin oedema	2	0%	0.76	fixed	3.29	2.25–4.81	<0.001
10	Administration of vasopressors	2	89.7%	<0.01	random	0.53	0.02–13.42	0.70
11	Glasgow score	2	0%	0.51	fixed	1.30	1.08–1.55	<0.001

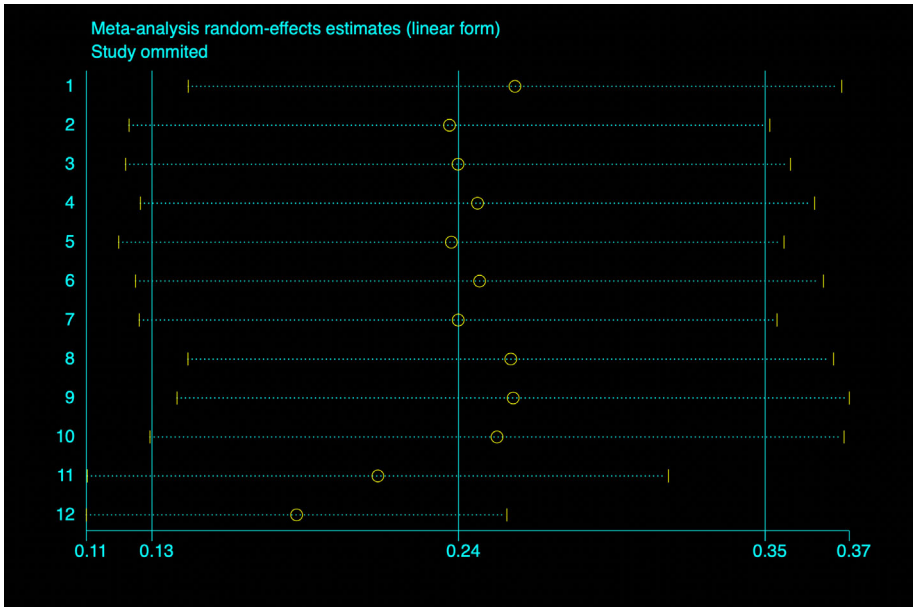

FIGURE 4 Sensitivity analysis

South America(n = 1). And regarding study design, 9 was of cross-sectional designs, 2 was cohort studies and 1 was of case–control study. 12 articles describe the prevalence of facial pressure injury and 9 articles describe risk factors for facial pressure injury. A summary of include literature characteristics can be found in Table 1.

4 | RESULTS OF THE META-ANALYSIS

4.1 | Prevalence of facial pressure injuries

In the 12 studies available for the meta-analysis, prevalence of facial pressure injuries from 3.9% to 100%. Based on a random-effects model-based meta-analysis conducted on all data points, the overall prevalence of facial pressure injuries related to adult non-invasive ventilation equipment was estimated to be 25% (95% CI: 15% to 37%, $I^2 = 97.34\%$, $P < 0.0001$ Figure 3).

4.2 | Stratified prevalence of facial pressure injuries according to pressure ulcer site, gender, countries, stages of pressure injuries

The estimates of pooled prevalence of facial pressure injuries for nose wings, cheek, bridge of nose and forehead were 5%, 3%, 29% and 4%, respectively. The estimates of pooled prevalence of facial pressure injuries were 8% in males and 5% in females. The prevalence of pressure injury in others was higher than that in China. Finally, facial pressure injuries occur mainly in stage I, stage II. The estimated pooled results obtained in subgroup analyses are shown in Table 2.

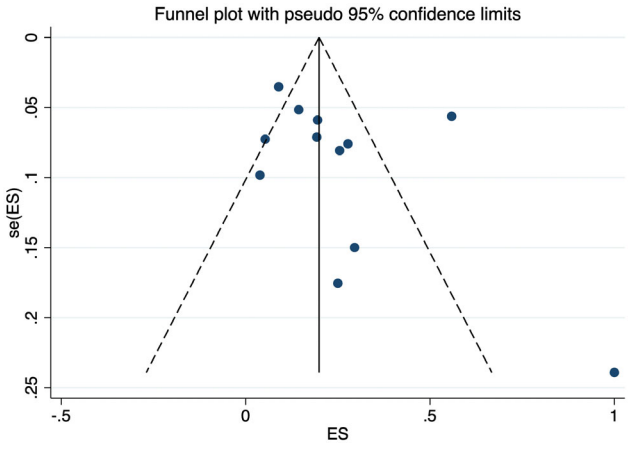

FIGURE 5 Funnel plot

4.3 | Risk factors

This study included a total of 11 risk factors of facial pressure injuries related to adult non-invasive ventilation equipment, include: age, use equipment form, with diabetes, Braden score, fever, cumulative time of using equipment, use hormone drugs, serum albumin, facial skin oedema, administration of vasopressors and Glasgow score. Among them, age, Braden score, use hormone drugs, serum albumin and administration of vasopressors are not statistically significant. Therefore, use equipment form, with diabetes, fever, cumulative time of using equipment, facial skin oedema and Glasgow score are risk factors for facial pressure injuries related to non-invasive ventilation equipment. The results of risk factors analysis are listed in Table 3.

4.4 | Publication bias

Sensitivity analysis (Figure 4) showed that there was no significant change in the pooled prevalence obtained when each study was excluded from the analysis. Funnel plot symmetry (Figure 5) revealed no evidence of publication bias among studies heterogeneity. Results of Egger's weighted regression test further confirmed the funnel plot symmetry ($P > 0.10$).

5 | DISCUSSION

Based on 12 studies included in the current meta-analysis, which involved a total of 2689 patients. The pooled prevalence of facial pressure injuries is 25%. The assessment of risk factors of facial pressure injuries related to adult non-invasive ventilation equipment indicated statistically significant correlation with five factors: use equipment form, with diabetes, fever, cumulative time of using equipment, facial skin oedema and Glasgow score.

The meta-analysis showed that there was obvious heterogeneity among the various studies. Combined with the results of subgroup analysis, the heterogeneity may be mainly due to differences in the study population methodology. In terms of population heterogeneity, the sample size of the patients included in the original studies, the age distribution of the patients, the sex ratio and the underlying diseases are all quite different, which may lead to a large difference in the prevalence of facial pressure injuries.

Prior studies[7,8] have mentioned non-invasive ventilation equipment as one of the main equipment for MDRPI. The prevalence of facial pressure injury with noninvasive ventilation in this study (25%) was higher

than 6.64% reported in a systematic review of the incidence and prevalence of medical device-related pressure ulcers in intensive care.[31] This may be related to the non-invasive ventilation device itself. Non-invasive ventilation masks are usually made of hard materials such as plastic or rubber, which can cause friction or pressure on the facial tissue leading to a high prevalence of pressure injuries.[32] Therefore, it is vital to prevent and reduce the prevalence of pressure injury related to noninvasive ventilation equipment in clinical practice.

Different prevalence of pressure injuries was found to be present between nose wings, cheek, bridge of nose, forehead. The bridge of the nose is one of the thinnest parts of the subcutaneous tissue on the nose and face.[33] The mask worn by patients using non-invasive ventilation equipment will exert a pressure of about 70 mmHg on the bridge of the nose.[34] When there is shear force, such as that generated between inspiratory and expiratory phases of ventilation and pressures as low as 30 mmHg may be enough to cause tissue damage within a few hours.[35] Therefore, the prevalence of pressure ulcers on the bridge of the nose is relatively high. Studies[36] have shown that the use of hydrocolloids can reduce the prevalence of non-invasive ventilation equipment related pressure injury, therefore, we advocate the use of hydrocolloid dressings to prevent pressure injury to the nasal bridge associated with non-invasive ventilation equipment.

The staging of pressure injury indicated that facial pressure injuries mostly occur in stageI, stageII, which may be related to the rapid progression of the patient's condition and relatively short treatment time. With the end of treatment and the removal of the mask, the patient's nasal and facial skin pressure disappears and the local skin pressure on the nasal and facial area disappears.[37] This may also be due to the fact that medical staff take steps to prevent the injury from deepening after discovering that patient had facial pressure injury. The above factors all indicate that the occurrence and development of pressure injury can be prevented. Therefore, in clinical nursing work, attention should be paid to the assessment of pressure injury to prevent its occurrence.

In the subgroup analysis, the prevalence of facial pressure injury in male patients using non-invasive ventilation was higher than that in female patients, which may be due to the imbalance of samples. Moreover, study showed significant association between smoking and development of pressure injury as well as its severity.[38] The number of men who smoke is higher than that of women.[39,40]

And the prevalence of pressure injury in China was lower than that in others. This may be related to the facial features of Chinese people. Studies[41] have shown that most Chinese people have a wide face and a middle nose type, so the face area is large. When receiving non-invasive ventilation mask treatment, the pressure is relatively small. Therefore, the prevalence of facial pressure injuries related to adult non-invasive ventilation equipment was low.

The risk factors of facial pressure injury related to non-invasive ventilation equipment are mainly two aspects: the situation of using the equipment and the patient's own factors. The situation of using the equipment include the form of using equipment and the time of using non-invasive ventilation equipment. Continuous use of non-invasive ventilation equipment and use of the equipment for too long will cause an increase in the prevalence of facial pressure injuries. This result is the same as that of Katherine M's[42]studies. Studies have shown that continuous pressure for 1–2 h can cause tissue damage and cell death, continuous pressure on the local skin for more than 2 h can cause the occurrence of pressure ulcers or aggravate the progress of pressure ulcer injury.[43,44] Therefore, the evaluation of early clinical pressure injury is very important. In clinical practice, when the patient's condition is stable or treatment permits, the use of non-invasive ventilation equipment can be suspended to avoid continuous use and use of the equipment for too long.

The patient's own factors include patient with diabetes, fever, facial skin oedemas and state of consciousness. First, the results of this study showed that diabetes was a risk factor for facial pressure injury, this result was the same as that of Lima Serrano M's[45]study. Diabetes patients have extensive small blood vessel endothelial hyperplasia, hypoxia and injury, diabetic peripheral neuropathy, low skin sensitivity, abnormal sweating (hyperhidrosis, less sweating or no sweating), which leads to changes in skin condition.[46,47] This leads to an increase in the risk of facial pressure injuries. Second, the results of this study showed that the risk of facial pressure injury in patients with fever was 4.94 times that of patients without fever. Fever patients sweat a lot, causing the skin to be in a moist state. Several researches show humidity of the skin as a factor involved in the increase of the risk of pressure injuries. The non-invasive ventilation mask needs to be in continuous and close contact with the patient's nose and face. The local sweat cannot evaporate in time, the moisture stimulates the epidermis, and the pH changes, which can weaken the barrier function of the stratum corneum of the skin, resulting in facial occurrence of pressure injury.[48] In addition, during fever the metabolic rate and oxygen consumption of the skin tissue will increase, and the resistance to external pressure and stimulation will decrease significantly, leading to the easy occurrence of facial pressure injury.[49] In

clinical practice, it is necessary to strengthen the facial skin care of patients with non-invasive ventilation to keep the skin dry. Liquid dressings and foam dressings can be used to prevent facial pressure injuries in high-risk patients.[50] Third, the results of this study showed that the risk of facial pressure injury in patients with oedema was 3.29 times that of patients without facial skin oedema. Liu Yan's research[51] also showed that oedema is a risk factor for pressure injury. When the patient is edematous, the interstitial fluid in the face increases, the tissue is swollen, the skin is tight, thin, and the elasticity is reduced. Long-term pressure can easily lead to facial pressure injury.[52] In addition, excessive fluid accumulation in the interstitial space may affect the oxygen and nutrient supply to the tissue, indirectly inducing pressure injury.[22,52] When using non-invasive ventilation equipment in patients with edema, attention should be paid to assessing the integrity of the skin, as well as actively treating the primary disease and improving nutritional status.[53] Fourth, the lower the Glasgow score, the higher the prevalence of a patient's facial pressure injury. When the patient is in a drowsy or even comatose state, the patient's sense of external stimuli is weakened,[54] so the patient cannot respond appropriately to the pressure of the mask, resulting in the occurrence of face pressure injury. Therefore, when using non-invasive ventilation equipment for patience with low Glass score, the evaluation of facial skin should be strengthened in clinical work.

6 | STRENGTH AND LIMITATIONS

A fundamental strength of the current analysis is the adoption of robust methodology. The comprehensive literature search was performed in 8 electronic databases and included publications in both English and Chinese language. This extensive effort, undertaken by two reviewers, enhanced the ability to accurately catalogue the entire information on facial pressure injury related to non-invasive ventilation equipment epidemiology and allowed stratifying the studies based on pressure ulcer site, gender, countries and stages of pressure injuries. To the best of our knowledge, the current study is the first to provide both the estimate of the pooled the prevalence and risk factors of facial pressure injuries related to adult non-invasive ventilation equipment. The results of this study are expected to be of value to nurses, clinicians, patients using non-invasive ventilation devices, and researchers. Nurses and clinicians should play an important role in the prevention, assessment, treatment and documentation of patients with facial pressure injuries to improve the quality of life of patients using non-invasive ventilation devices. Given the high prevalence of facial pressure injury and its preventability, researchers should focus on studying its effective preventive measures and unifying its effective assessment tools to provide a basis for the treatment and care of facial pressure injury in the future.

Potential limitations of the present work should be noted. First, in this study, only 2 literatures were included for some of the risk factors of facial pressure injury related to non-invasive ventilation equipment, which may lead to biased conclusions. Therefore, relevant factors can be included for multivariate analysis in the future to further explore and clarify the risk factors of facial pressure injury related to non-invasive ventilation equipment, and lay a foundation for taking corresponding intervention measures as soon as possible. Second, due to the different diagnostic tools, observation frequency and time used in each study, the included survey results are relatively scattered and have large heterogeneity. Give the obvious heterogeneity the results of the pooled analysis should be interpreted with caution. Thirdly, the languages of the included studies were limited in English and Chinese, the exclusion of works published in other languages limited the comprehensiveness of the included literature. Finally, the number of included studies was small ($n = 12$), and most studies being from China may compromise the external validity of the results found, so we should interpret the results carefully.

7 | CONCLUSION

The current analysis indicated an overall pooled prevalence of facial pressure injuries related to adult non-invasive ventilation equipment of 25%. Use equipment form, with diabetes diseases, fever, cumulative time of using equipment, facial skin oedema and Glasgow score were identified as risk factors of facial pressure injuries related to adult non-invasive ventilation equipment. Understanding the risk factors of facial pressure injuries can provide the healthcare personnel with the theoretical basis for the management and treatment of the patients.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

DATA AVAILABILITY STATEMENT

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

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