



Review article

Positive and negative factors of parents vaccinating their children against COVID-19: An umbrella review

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ABSTRACT

Purpose: This umbrella review summarized the factors influencing parents' hesitancy to vaccinate their children against COVID-19 and the evidence to reduce it.

Methods: The analysis included PubMed, Embase, Cochrane Library, Web of Science, and Scopus articles published before March 22, 2024. It considered all *meta*-analyses that investigated parental COVID-19 vaccine hesitancy.

Results: Eight studies were included. Hesitancy rate of parents from five continents to vaccinate their children against COVID-19 was between 0.69 % and 95.0 %. The comprehensive synthesis in this review shows that the influencing factors originate from four aspects: Parents' attitudes, including their trust in the scientific community, concerns about COVID-19 complications, perceptions of children's susceptibility, and support from the social environment, including government incentives, low vaccination costs, and specific sociodemographic characteristics, were positive factors that reduced parental vaccine hesitancy in children. Conversely, negative aspects, including vaccine distrust, the spread of misinformation, poor economic status, and concern about unprecedentedly short development time, were associated with increased hesitancy.

Conclusion: Our study identified positive and negative factors for parental COVID-19 vaccine hesitancy in children and highlighted that parental attitude was the most important determinant.

1. Introduction

Coronavirus disease 2019 (COVID-19) was caused by a novel coronavirus that rapidly resulted in severe respiratory syndrome and lethal pneumonia in Wuhan, China, at the end of 2019 (Cucinotta and Vanelli, 2020). The pandemic has profoundly impacted the global healthcare system, economic development, and social order. As of March 15, 2024, more than 774 million confirmed cases were reported globally (World Health Organization, 2024). Therefore, there is an urgent need for the development of appropriate countermeasures. During the COVID-19 pandemic, nonpharmaceutical interventions (NPI) such as lockdowns, stay-at-home orders, school closures, and travel restrictions have been implemented to hinder the spread of the virus (Patiño-Lugo et al., 2020). However, unintended consequences of public health were also led to by NPI at the same time, such as mental health and lifestyle risk factors for

non-communicable diseases: physical activity, overweight, and obesity (ÓhAiseadha et al., 2023), especially in children (Meherali et al., 2021).

Vaccination is the safest and the most effective health intervention (Meherali et al., 2018). Vaccination against many infectious diseases, such as smallpox, diphtheria, and rubella, has been successfully implemented worldwide and is controlled by others (Andre et al., 2008; Alimoradi et al., 2023). However, challenges remain in vaccine development. Vaccine hesitancy, as defined by the World Health Organization (WHO), refers to a delay in the acceptance or refusal of vaccination despite the availability of vaccination services and has emerged as a global challenge for vaccination (MacDonald, 2015; Ryan and Malinga, 2021). As herd immunity, children's immunization is hindered by the vaccine hesitancy of their parents to vaccinate their children against COVID-19. Regarding children's vaccination, parents are usually the decision-makers. Positive factors can increase parents' willingness to

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vaccinate their children and reduce hesitation, whereas negative factors can decrease parents' willingness and hesitancy (Alimoradi et al., 2023). Therefore, exploring the negative and positive factors affecting parental COVID-19 vaccination in children is essential. Numerous meta-analyses and systematic reviews have investigated the factors influencing parental vaccination of children with COVID-19. The influencing factors explored in all the meta-analyses and systematic reviews can be summarized as positive or negative, including sociodemographic characteristics, social environment, parents' attitudes, and factors related to the COVID-19 vaccine. Umbrella reviews can provide a comprehensive and holistic understanding of an issue by systematically collecting and screening systematic reviews and meta-analyses and providing the highest level of evidence (Papatheodorou and Evangelou, 2022; Jiesi-siebieke et al., 2023). However, few umbrella reviews have explored the factors influencing parental COVID-19 vaccine hesitancy in their children.

The coronavirus disease (COVID-19) pandemic has spread worldwide, causing severe economic and social disruptions and posing a substantial threat to human health. Analyzing and summarizing the factors influencing parental hesitancy to vaccinate children against COVID-19 helps solve this challenge and gain experience in preparing for the future impact of the pandemic. This umbrella review addressed the following issues thoroughly: 1) the current status of parental COVID-19 vaccine hesitancy in children, 2) positive and negative factors influencing parental hesitancy, and 3) strategies for decreasing parental vaccine hesitancy in COVID-19.

2. Methods

2.1. Search strategy and eligibility criteria

To generate comprehensive results, references for this review were identified by searching PubMed, Embase, the Cochrane Library, Web of Science, and Scopus for related studies from their inception until March 22, 2024. The search strategy was developed according to the population-exposure-outcome (PEO) criteria and included key and MESH terms related to the COVID-19 vaccine, vaccination hesitancy, parents, and children adjusted in each database. No other restrictions are imposed. The search string is shown in the [Supplementary Material Checklist 1](#). Two authors (HW and C-LH) independently searched the databases, and in case of disagreements, a third author (J-SZ) resolved any conflicts, reaching a consensus between the two authors. All the studies were screened using EndNote 20.

Meta-analyses and systematic reviews of observational studies that examined parents' hesitancy to vaccinate their children against COVID-19 were included. We excluded studies that were not meta-analyses or systematic reviews, were not related to vaccine hesitancy, were not related to parents, or were not associated with COVID-19. All articles from the initial literature search were entered into EndNote X20 Reference Manager. After removing duplicates, two authors (HW and C-LH) independently searched the titles and abstracts for eligibility. The full texts of potentially relevant articles were then carefully read and assessed against the inclusion and exclusion criteria by the same authors. Any disagreements between the two authors were resolved by consensus with a third author (J-SZ). The study selection process is summarized in the PRISMA flowchart (Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart) (Fig. 1). This review

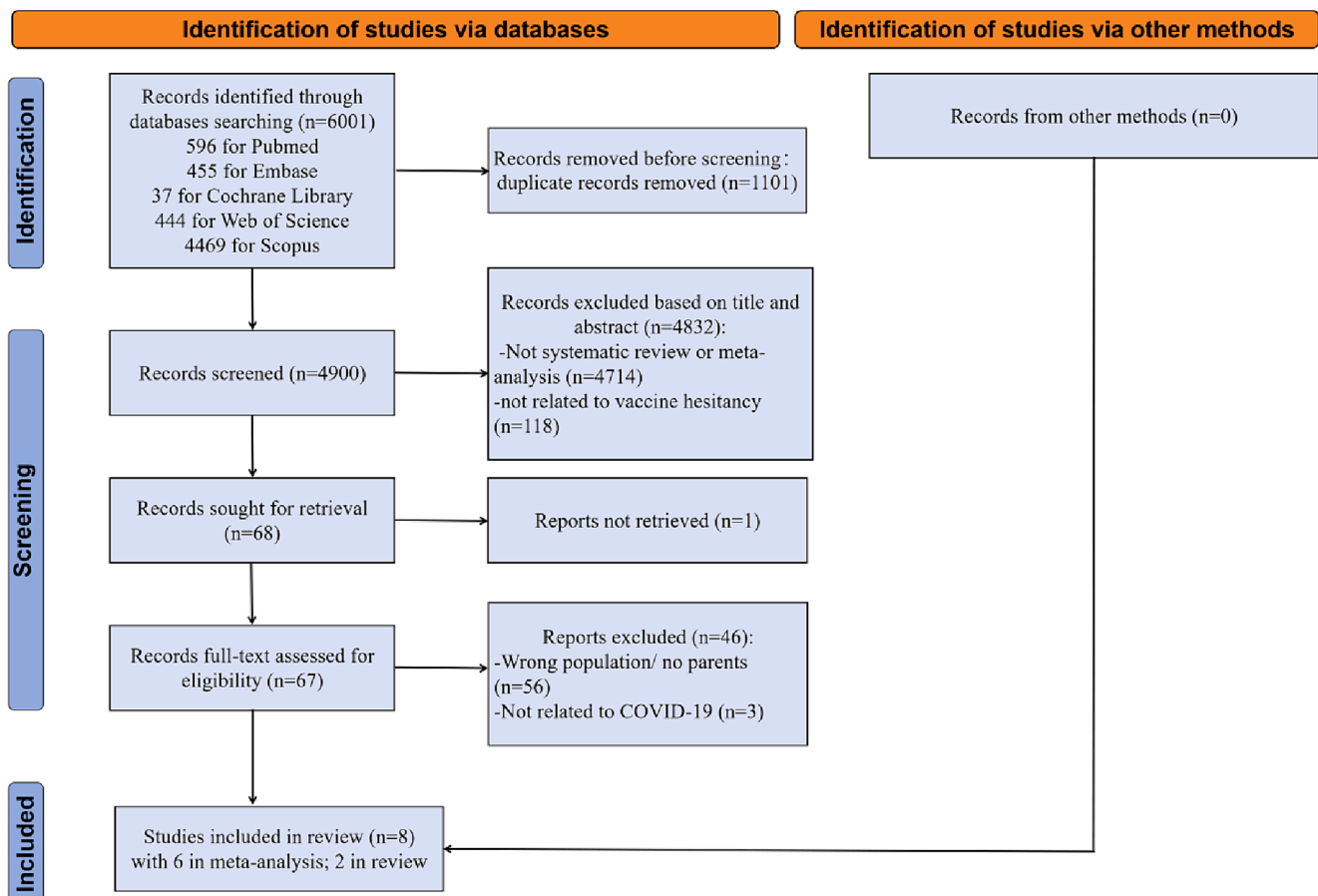


Fig. 1. Preferred reporting items for Systematic reviews and Meta-Analyses (PRISMA) 2020 flow chart.

was registered in the International Prospective Register of Systematic Reviews (PROSPERO ID: 42023463445).

2.2. Data extraction

After systematically reviewing *meta*-analyses and reviews, articles that met the inclusion criteria were selected. Subsequently, the following data were extracted from the articles: year, author, country, evidence reviewed, number of primary studies, population, study design included in the *meta*-analyses, sample size per included *meta*-analysis, vaccine acceptance rate, vaccine hesitancy rate, I2 statistical significance, strategies to decrease parental vaccine hesitancy, and Meta-Analyses models (Table 1). We conducted a regional analysis of the data from the original studies for five continents: Asia, Europe, Africa, the Americas, and Oceania (Supplementary Material Checklist 2). Data were extracted and validated by one and two reviewers, respectively.

2.3. Assessment of methodological quality

Two authors independently followed the AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews 2) guidelines, a measurement tool used to assess systematic reviews to assess the methodological quality of the included systematic reviews and *meta*-analyses. A third author played a decisive role in resolving any disagreements. Due to its broad coverage, AMSTAR 2 is often used in umbrella reviews (Poole et al., 2017; Tsai et al., 2022). The guidelines contained 16 terms, with seven items considered critical. Any critical domain with deficiencies can affect the overall effectiveness of a review (Okoth et al., 2020). The severe limitation of the studies included may be obscured by high total points and be considered high-quality studies; therefore, a total score was not provided (Shea et al., 2017; Swierz et al., 2021) (Supplementary Material Checklists 3).

2.4. Assessment of epidemiological credibility

In clinical practice, recommendations are more robust when supported by more substantial evidence. As mentioned by Bellou et al., high epidemiological reliability denotes the most substantial available evidence, with no indication of significant variance or bias (Bellou et al., 2018). The following categories were used to classify the level of evidence in the included studies (Gu et al., 2021):

- i. Persuasive: statistical significance per the random-effects model of $p < 0.000001$, more than 1,000 cases, low heterogeneity among the selected studies ($I^2 < 50\%$), 95 % Confidence Interval (CI) (excluding the null value), and no evidence of small study effects or significant bias;
- ii. Highly recommended: statistical significance of $p < 0.000001$, more than 1,000 cases, and most studies indicating a significant effect;
- iii. Recommended: more than 1,000 cases and significant effects at $p < 0.001$;
- iv. Weak evidence: nominally significant associations ($p < 0.05$);
- v. Poor evidence: obtained from samples with less than 1,000 cases. (Patiño-Lugo et al., 2020)

3. Results

3.1. Study characteristics

After excluding duplicates, 6001 articles were screened for eligibility, of which eight *meta*-analyses or systematic reviews that complied with the eligibility criteria were included in our review (Fig. 1). These eight studies were published between 2022 and 2023. Characteristics of the systematic reviews and *meta*-analyses are presented in Table 1. Most selected studies involved parents from multiple countries. One study

focused on parental vaccine hesitancy in low- and middle-income countries (L&MICs) (Abu El Kheir-Mataria et al., 2023). One study reported that the parental COVID-19 vaccine hesitancy rate of their children was 55.1 % (95 % confidence interval [CI]: 43.8 ~ 66.1 %) (Bianchi et al., 2023), and the other study reported that the parental hesitancy rate for COVID-19 vaccines was observed to be 44.2 % with a SD of $\pm 19.7\%$ across Middle Eastern countries (Iqbal et al., 2023). Vaccine hesitancy Similarly, five studies reported the outcome of vaccine acceptance rate to assess parental vaccine hesitancy, which ranged from 44.2 % to 70 % (Alimoradi et al., 2023; Abu El Kheir-Mataria et al., 2023; Galanis et al., 2022; Ma et al., 2022; Chen et al., 2022). The included studies were classified into several groups. Six of the included studies could be classified as “recommended.” Two studies were considered “weak evidence” (Iqbal et al., 2023; Khan et al., 2022).

3.2. Outcome analysis

Parents' COVID-19 hesitancy rate of children was between 0.69 % and 95.0 %. Simultaneously, factors influencing parental vaccine hesitancy were explored and divided into four aspects: parental attitude towards COVID-19 and the vaccine, social environment, sociodemographic characteristics, and the vaccine itself.

3.2.1. Parental attitude towards COVID-19 and vaccine

Regarding parental attitude, all studies show that it is an important issue impacting parental vaccine hesitancy to vaccinate their children against the COVID-19 vaccine. Parents trusting the scientific community, accepting the notion of a vaccine, or vaccinating themselves against COVID-19 were more willing to vaccinate their children (Alimoradi et al., 2023; Abu El Kheir-Mataria et al., 2023; Bianchi et al., 2023; Iqbal et al., 2023; Ma et al., 2022; Chen et al., 2022). Two studies also showed that parents were more concerned about COVID-19 and perceived their children's susceptibility to COVID-19 were positive to vaccinate their children (Bianchi et al., 2023; Ma et al., 2022). In contrast, all of them agreed that parents concerned about the possible side effects, safety, and efficacy of COVID-19 vaccine hesitated to vaccinate their children. One study analyzed 14 studies and found that parents hesitated to be vaccinated because of concerns about potential COVID-19 exposure during vaccination (Abu El Kheir-Mataria et al., 2023).

3.2.2. Social environment

Regarding social and environmental factors, misinformation has made parents hesitate to use the COVID-19 vaccine (Bianchi et al., 2023; Ma et al., 2022; Chen et al., 2022; Khan et al., 2022). One study showed that good vaccine accessibility and government incentives encouraged parents to vaccinate their children against COVID-19 (Khan et al., 2022).

3.2.3. Sociodemographic characteristics

Sociodemographic characteristics are also a critical aspect impacting parental vaccine hesitancy. Most studies included in our review collected and analyzed information from multiple countries (Alimoradi et al., 2023; Abu El Kheir-Mataria et al., 2023; Galanis et al., 2022; Chen et al., 2022; Khan et al., 2022). One study was limited to Italy, with a pooled prevalence of vaccine hesitancy of 55.1 %, and one was limited to China, with a pooled prevalence of vaccine acceptance of 65.0 % (Bianchi et al., 2023; Ma et al., 2022). One study showed the acceptance of COVID-19 vaccination for children was higher among parents from Asia than those from North America and Europe (Galanis et al., 2022). One study showed that the acceptance of COVID-19 vaccination for children was higher among parents from Asia than those from North America and Europe (Galanis et al., 2022). However, one other study by Chen and his co-workers showed that the acceptance of COVID-19 vaccination for children was higher among parents from Asia (58.3 %) than those from North America (52.3 %) but lower than those from Europe (51.0 %) (Chen et al., 2022). According to the original studies of

Table 1
Characteristics of the included studies.

No.	Author	Year	Country	Evidence reviewed	No. of primary studies	Population	Study design included in meta-analyses	Sample size per included meta-analysis	Vaccine acceptance rate	Vaccine hesitancy rate	I ²	Statistical significance	Strategy	Meta-Analyses models	Study quality
1	Francesco Paolo Bianchi (Bianchi et al., 2023)	2023	Italy	January 1, 2020 to July 23, 2022	10	parents/caregivers of minor	cross-sectional study, parental attitude study	11,236	Not Appropriate	55.1 % (95 % CI: 43.8 ~ 66.1 %)	99.20 %	p < 0.0001	Communication campaigns and educational programs about the safety of childhood vaccinations; Make full use of the authoritative role of medical workers, especially pediatricians.	Random-effects models	Critically low
2	Wafa Abu El Kheir-Mataria (Abu El Kheir-Mataria et al., 2023)	2023	Multi-country	December 2021 to February 2022	13	the L&MICs population, of parents, caregivers, and guardians	cross-sectional study	13,676	49 % (95 % CI: 37.3 ~ 60.9 %)	Not Appropriate	Not Appropriate	p < 0.0001	Enlist the help of healthcare providers.	Random-effects models	Critically low
3	Petros Galanis (Galanis et al., 2022)	2022	Multi-country	inception to 12 December 2021	44	parents and guardians of children aged < 18 years	cross-sectional study	317,055	60.1 % (95 % CI: 51.7 ~ 68.1 %)	refuse 22.9 % (95 %CI: 17.3 ~ 29.0 %) unsure 25.8 % (95 %CI: 20.0 ~ 32.0 %)	99.91 %	p < 0.001	Tailored and targeted communication materials and balanced information on vaccines; A robust, transparent, reasonable, and widespread COVID-19 vaccine educational campaign harnessing media, healthcare workers, leaders, and social influencers; Emphasize the safety of vaccines for children based on evidence from randomized controlled trials and post-approval data.	Random-effects models	Low
4	Yundi Ma (Ma et al., 2022)	2022	China	December 2019 to June 2022	13	adult participants (>18 years) with children aged 3 to 17 years in China	cross-sectional study	47,994	70.0 % (95 % CI: 62.0 ~ 78.0 %)	Not Appropriate	99.70 %	p < 0.001	Make full use of the media to distribute the accuracy and objectivity of information and suggestions on the epidemic; Government agencies need to explain the safety, accessibility, side effects, and efficacy of the COVID-19 vaccine in a more professional and scientific way; Government should disclose more openly and transparently information about vaccine.	Random-effects models	Low
5	Feifan Chen (Chen et al., 2022)	2022	Multi-country	inception to 6 November 2021	29	adult participants (>18 years of age) who were parents or guardians of minors	cross-sectional study	68,327	61.40 % (95 % CI: 53.56 ~ 68.69 %)	Not Appropriate	99.30 %	p = 0.000	Clarifying the side effects of COVID-19 vaccines; Scientific information and recommendations.	Random-effects models	Moderate

(continued on next page)

Table 1 (continued)

No.	Author	Year	Country	Evidence reviewed	No. of primary studies	Population	Study design included in meta-analyses	Sample size per included meta-analysis	Vaccine acceptance rate	Vaccine hesitancy rate	I ²	Statistical significance	Strategy	Meta-Analyses models	Study quality
6	Zainab Alimoradi (Alimoradi et al., 2023)	2023	Multi-country	December 2019 to July 2022	98	parents or children's guardian with no limitation regarding their demographic characteristics	cross-sectional study, cohort study, case-control study	413,590	57 % (95 % CI: 52 ~ 62 %)	Not Appropriate	99.92 %	p = 0.000	Governments and health authorities should have appropriate methods to maintain willingness of having children vaccinated among parents.	Random-effects models	Moderate
7	Yusra Habib Khan (Khan et al., 2022)	2022	Multi-country	January 2020 to August 2022	108	parents of children up to 12 years without a diagnosis of COVID-19	cross-sectional study, cross-sectional online survey, mixed method study, correlational study, sequential explanatory mixed method design, parental attitude study	653,466	Not Appropriate	Not Appropriate	Not Appropriate	Not Appropriate	Sharing of non-factual data should be avoided through social media and the provision of accurate scientific information should be encouraged.	Not Appropriate	Critically low
8	Muhammad Shahid Iqbal (Iqbal et al., 2023)	2023	Middle Eastern Countries	January 2020 to December 2022	25	parents	cross-sectional study	33,558	Not Appropriate	44.2 % (SD ± 19.7 %)	Not Appropriate	Not Appropriate	Healthcare authorities and health policy makers should address the reasons for COVID-19 vaccine hesitancy among parents and promote productive, beneficial and valuable awareness regarding the benefits of the COVID-19 vaccine for children	Not Appropriate	Critically low

the *meta*-analyses and systematic reviews included in our review, the parental COVID-19 vaccine hesitancy was between 8.44 % to 95.0 % in Asia, 8.4 % to 75.0 % in Europe, 0.69 % to 81.5 % in Africa, 2.8 % to 86.1 % in America, and 8.0 % to 52.0 % in Oceania. Vaccine hesitancy varies across continents and regions, which may be related to local policies, the severity of the epidemic, and economic conditions.

Most studies included in our review showed that parents with poor socioeconomic status were hesitant to vaccinate their children (Abu El Kheir-Mataria et al., 2023; Bianchi et al., 2023; Chen et al., 2022). One study showed that parents from urban areas were more willing to vaccinate their children than those from rural areas (Khan et al., 2022). In addition, the age of the children is an essential factor. A higher expression of vaccine hesitancy among parents of minors (55.1 %) than among parents of adolescents (51 %) was reported (Bianchi et al., 2023). Evidence regarding the effect of parental sex on vaccine hesitancy is scarce. Two studies reported that females were more hesitant than males (Galanis et al., 2022; Khan et al., 2022). However, parental age and educational level were disputed among the studies included in our review. Regarding parental education level, two studies agreed that the high education of parents was a positive factor and low education was a negative factor (Abu El Kheir-Mataria et al., 2023; Bianchi et al., 2023). However, other studies have shown that education is a controversial factor. Most of these studies agreed that younger parents were more hesitant to vaccinate their children (Bianchi et al., 2023; Galanis et al., 2022; Chen et al., 2022; Khan et al., 2022). However, one study showed that parental age was a contentious factor (Ma et al., 2022).

3.2.4. Factors from the vaccine itself

Factors associated with the vaccine also affect parental vaccine hesitancy. Two studies in our review showed that the short duration of COVID-19 vaccine development and the reported side effects hindered parents from vaccinating their children (Iqbal et al., 2023; Chen et al., 2022). One study reported that the low cost of the COVID-19 vaccine encouraged parents to vaccinate their children (Khan et al., 2022).

These factors were analyzed in the studies included in our review. A comprehensive synthesis in this review found that positive factors weakening parental COVID-19 vaccine hesitancy for their children were trust in vaccination (e.g., history of children's routine vaccination and parental COVID-19 vaccination), concerns about children's COVID-19 infection, government incentives, good vaccine accessibility, low cost of vaccination, and stable family ecological status. Contrarily, negative factors were distrust in the vaccines (e.g., concerns about the safety, efficacy, and possible side effects of COVID-19 vaccines), the spread of misinformation, an unprecedentedly short development time, and reported side effects of COVID-19 vaccines, and relatively poor economic status.

3.3. Outcome measurement

However, the outcome measurement tools used in the *meta*-analysis differed. Descriptive analysis was performed in almost every study. Bianchi et al. obtained the pooled proportion using the Freeman-Tukey double arcsine transformation to stabilize variances and DerSimonian-Laird weights for random-effects models. They also explored the relationship between vaccine hesitancy and predictors like age, sex, and education, using odds ratios (ORs) and 95 % CI (Bianchi et al., 2023). Kheir-Mataria et al. measured parental acceptance proportions using the arcsine proportion and fixed effect models (Abu El Kheir-Mataria et al., 2023). Using the Freeman-Tukey Double Arcsine method, Galanis et al. calculated the proportion of parents who intended, refused, and were unsure about vaccinating their children with COVID-19 (Galanis et al., 2022). Alimoradi et al. and Chen et al. estimated global parental willingness for children's COVID-19 vaccination by conducting a random-effect *meta*-analysis of single proportions using software R 4.1.2 and separately with STATA (Ma et al., 2022; Chen et al., 2022). Although different methods were used, the current status of vaccine hesitancy and

its influencing factors were thoroughly analyzed.

3.4. Publication bias

Additionally, publication bias assessments differed among the eight included studies. Four studies did not use funnel plots to assess publication bias (Abu El Kheir-Mataria et al., 2023; Bianchi et al., 2023; Iqbal et al., 2023; Khan et al., 2022). One study used the "Cochrane Bias" tool of LvE for risk assessment to rule out the risk of biasness, and this biasness assessment was further verified by KT, HdG and LvD (Iqbal et al., 2023). One study used funnel plots and Egger's test to assess publication bias, which indicated a potential publication bias ($p < 0.05$) in parental willingness to vaccinate children with COVID-19; parents reported being unsure about their children's COVID-19 vaccination (Galanis et al., 2022). Two studies used funnel plots and Egger's test to evaluate publication bias, and their results found no evidence of publication bias ($p > 0.05$) (Ma et al., 2022; Chen et al., 2022). One study used funnel plot and Begg's test to assess publication bias, and the results showed a potential publication bias (Alimoradi et al., 2023). The fill-and-trim method was subsequently used to rectify potential publication bias; however, no study was attributed, leading to the exclusion of publication bias.

3.5. Residual confounding

All the studies included in this review were observational. Thus, we could not conclude a causal relationship between the above mentioned factors and parental vaccine hesitancy against COVID-19 in children. Owing to confounding and selection biases, there may be some residual confounding factors when studying the correlation between the referred factors and vaccine hesitancy.

4. Discussion

4.1. Clinical implications and practice

Since a public health event as substantial as the COVID-19 pandemic is unpredictable and inevitable, systematic reviews and *meta*-analyses on parental vaccine hesitancy to vaccinate their children with the COVID-19 vaccine during the pandemic were included and systematically analyzed for the determinants of parental vaccine hesitancy in this umbrella review. Factors influencing parental COVID-19 vaccine hesitancy in their children were classified into four categories: parental attitude towards COVID-19, social environment, sociodemographic characteristics, and the vaccine itself. We analyzed the parental vaccine hesitancy to their children's COVID-19 vaccine in five continents. These findings provide evidence for reducing parental vaccine hesitancy to COVID-19 and information for quickly responding to potential global public health crises. These findings can be applied to foster other vaccinations in children. Successful vaccination can effectively reduce the incidence of vaccine-preventable disease incidence (Nabel, 2013). Vaccination is the safest method for protecting children from life-threatening diseases. However, estimates from the Global Alliance for Vaccines and Immunization suggest that approximately 25 million children are missing out on life-saving vaccines every year, placing them at risk of preventable diseases such as measles and pertussis. Considering this situation, the factors that prevent parents from vaccinating their children are essential for improving vaccination rates.

The studies included in our review showed that the vaccine hesitancy rate among parents was between 0.69 % and 95.0 %. The vaccine hesitancy rate was different across continents: 8.44 % to 95.0 % in Asia, 8.4 % to 75.0 % in Europe, 0.69 % to 81.5 % in Africa, 2.8 % to 86.1 % in the Americas, and 8.0 % to 52.0 % in Oceania, which may be related to different local policies, the severity of the epidemic, and economic conditions. Positive factors decreasing parental vaccine hesitancy for COVID-19 included parental attitude (e.g., trust in the scientific

community and authorities, concerns about complications related to COVID-19, and perceptions of children's susceptibility), social environment (e.g., good vaccine accessibility and government incentives), sociodemographic characteristics (e.g., older age of children, parents with a history of COVID-19 infection, and parents with a history of vaccination), and the vaccine itself (e.g., low cost). In contrast, the negative factors that can promote parental vaccine hesitancy summarized in this review were parental attitudes that were concerned about the safety, efficacy, and potential side effects of COVID-19 vaccines, the dissemination of misinformation about COVID-19 vaccines, an unstable family economy, and factors from the vaccine itself, such as an unprecedented short development time and reported side effects of COVID-19 vaccines.

Importantly, parental attitudes are regarded as determinants of improved vaccine compliance. Parents who trust in the scientific community and authorities are willing to accept the notion of vaccines (Alimoradi et al., 2023; Abu El Kheir-Mataria et al., 2023; Bianchi et al., 2023). Similarly, parents who vaccinated themselves or whose children had a completed vaccination history showed higher trust in vaccination and were more likely to vaccinate their children against COVID-19 (Bianchi et al., 2023; Galanis et al., 2022; Ma et al., 2022; Chen et al., 2022). Conversely, parents who lack information about vaccination are more concerned about the safety, efficacy, and side effects of COVID-19 vaccines (Alimoradi et al., 2023; Abu El Kheir-Mataria et al., 2023; Bianchi et al., 2023; Iqbal et al., 2023; Galanis et al., 2022; Ma et al., 2022; Khan et al., 2022). However, the acceptance of misinformation by parents facilitates parental distrust of vaccines. Parents need help distinguishing between genuine and fake explosive information on social media. Official advice guides parents in making correct judgments.

Regarding COVID-19 vaccines, federal, state, and local levels, as well as healthcare professionals, are regarded as the most trusted sources of information (Scherer et al., 2021). Therefore, social media must be regulated to become a powerful instrument for distributing accurate scientific information on COVID-19 vaccines. Simultaneously, public health officers should engage in community vaccination campaigns, use media to communicate with parents, inform them of the safety and significance of COVID-19 vaccines, and provide scientific information and recommendations for parents to vaccinate their children against COVID-19.

Given that COVID-19 is a unique disease, factors from the vaccines also affect parental vaccine hesitancy. According to the clinical development process for a novel preventive vaccine, humans' safety, immunogenicity, and protective efficacy should be evaluated before the vaccine is licensed (Singh and Mehta, 2016). However, conventional vaccine approval processes may be waived during a pandemic, and some vaccine candidates may be given a fast-track status (Goldman et al., 2020; Eyal et al., 2020). This novel and rapid development has led to parental distrust in COVID-19 vaccines. Hence, public health officials should present the safety of COVID-19 vaccines in children based on randomized controlled trials and post-approval data (Iqbal et al., 2023; Galanis et al., 2022). Governments should openly and transparently disclose information on COVID-19 vaccine research, including development processes, safety, and validity testing. A comprehensive scientific understanding of COVID-19 vaccines is conducive to increasing parental trust in the COVID-19 vaccine and reducing parental vaccine hesitancy.

4.2. Strengths and limitations

Few umbrella reviews have explored factors associated with parental vaccine hesitancy in children vaccinated against COVID-19. This issue has received attention because children play an essential role in achieving herd immunity, and parental vaccine hesitancy poses a challenge to children's COVID-19 vaccination. Many groups have explored factors influencing parental COVID-19 vaccine hesitancy. Our umbrella here systematically summarizes these findings from four aspects,

especially the parental COVID-19 vaccine hesitancy from different continents. It has provided information on future vaccine hesitancy for future pandemics and similar vaccine hesitancy for other diseases.

Nevertheless, this study has several limitations. First, owing to the different outcomes and effect sizes of the included studies, it was difficult to gain the pooled results. Second, most studies included in our review had a cross-sectional design. These studies cannot develop causal relationships because they collect data over a minor span. Third, our review was limited to studies published in English. Fourth, none of the included studies used a standardized instrument to assess parental vaccine hesitancy. No quantitative measures were used to show the intensity of the determinants of parental vaccine hesitancy, and the included studies did not clearly define the term 'child.' Finally, high-quality meta-analyses investigating the factors influencing parental vaccine hesitancy are lacking. Therefore, high-quality meta-analyses or systematic reviews should be conducted to assess factors influencing parental vaccine hesitancy.

5. Conclusion

Several positive and negative factors related to parental vaccine hesitancy in children vaccinated against COVID-19 have been identified during public health emergencies. Since public health events are unpredictable and unavoidable, in addition to openly and transparently providing scientific information, the public health and government should increase parental awareness and trust in COVID-19 vaccines to reduce vaccine hesitancy.

6. Note

The authors have no proprietary interest in any aspect of this study.

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CRediT authorship contribution statement

Hui Wu: Writing – review & editing, Writing – original draft, Software, Resources, Methodology, Formal analysis, Data curation. **Chun-Lian Huang:** Writing – review & editing, Software, Data curation, Conceptualization. **Jing-Shan Deng:** Writing – review & editing, Methodology, Data curation, Conceptualization. **Chen-Qian Ying:** Writing – review & editing, Supervision, Data curation. **Tao-Hsin Tung:** Writing – review & editing, Writing – original draft, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Jian-Sheng Zhu:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pmedr.2024.102724>.

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