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Review Article

Willingness, refusal and influential factors of parents to vaccinate their children against the COVID-19: A systematic review and meta-analysis

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ARTICLE INFO

Keywords: COVID-19 Vaccination Willingness Predictors Refusal Children Parents

ABSTRACT

We aimed to estimate parents’ willingness and refusal to vaccinate their children against the COVID-19, and to investigate the predictors for their decision. We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines. We searched Scopus, Web of Science, Medline, PubMed, CINAHL and medrxiv from inception to December 12, 2021. We applied a random effect model to estimate pooled effects since the heterogeneity was very high. We used subgroup analysis and metaregression analysis to explore sources of heterogeneity. We found 44 studies including 317,055 parents. The overall proportion of parents that intend to vaccinate their children against the COVID-19 was 60.1%, while the proportion of parents that refuse to vaccinate their children was 22.9% and the proportion of unsure parents was 25.8%. The main predictors of parents’ intention to vaccinate their children were fathers, older age of parents, higher income, higher levels of perceived threat from the COVID-19, and positive attitudes towards vaccination (e.g. children’s complete vaccination history, history of children’s and parents’ vaccination against influenza, confidence in vaccines and COVID-19 vaccines, and COVID-19 vaccine uptake among parents). Parents’ willingness to vaccinate their children against the COVID-19 is moderate and several factors affect this decision. Understanding parental COVID-19 vaccine hesitancy does help policy makers to change the stereotypes and establish broad community COVID-19 vaccination. Identification of the factors that affect parents’ willingness to vaccinate their children against COVID-19 will provide opportunities to enhance parents’ trust in the COVID-19 vaccines and optimize children’s uptake of a COVID-19 vaccine.

1. Introduction

Given the human, social and economic burden of the Coronavirus disease 2019 (COVID-19) pandemic, the uptake of a safe and effective vaccine remains a critical strategy to curb its impact (Graham, 2020). Simulation experiments revealed that up to 80% of the population needs to receive a COVID-19 vaccine that is at least 80% effective to largely extinguish the COVID-19 pandemic with any other non-pharmaceutical measures (e.g., social distancing, masks, etc.) (Bartsch et al., 2020). Thus, COVID-19 vaccine uptake among children will be instrumental in limiting the spread of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the disease.

COVID-19 vaccine uptake relies on adequate production, fair distribution, and high levels of acceptance among the general public (Neumann-Böhme et al., 2020). Recent meta-analyses found that the overall COVID-19 vaccine acceptance rate was approximately 73%, while acceptance among the general population is higher than among healthcare workers (Galanis et al., 2021; Luo et al., 2021; Snehota et al., 2021; Wang et al., 2021b). Also, real-world data from early studies reveal that COVID-19 vaccination uptake ranges from 28.6% to 98% in the general population (Galanis et al., 2021a). Several factors influence vaccination intention and uptake in the general population such as sociodemographic characteristics, attitudes towards vaccination, psychological factors, perceptions of risk and susceptibility to COVID-19, knowledge, information, personal factors, medical conditions, etc. (Al-Amer et al., 2021; Galanis et al., 2021a; Snehota et al., 2021; Wake, 2021).
The risk of severe illness and death from the COVID-19 remains quite low for children, but children COVID-19 cases rise sharply due to the highly transmissible delta variant (Tanne, 2021). For instance, since the COVID-19 pandemic began, children represent 14.4% of total COVID-19 cases in the USA but for the week ending August 12, 2021, children were 18% of weekly cases (American Academy of Pediatrics, 2021). Moreover, children make up about 2.4% of total hospitalizations in the USA and about 1% of all pediatric COVID-19 cases resulted in hospitalization since the start of the pandemic (American Academy of Pediatrics, 2021). Additionally, preliminary findings show that a recent mutation of SARS-CoV-2 (omicron variant) is spreading faster than any previous variant and may be more transmissible than other coronavirus variants (Dyer, 2021; Mahase, 2021). Thus, there is a need for safe and effective COVID-19 vaccines for children of all ages as swiftly as possible (Tanne, 2021).

Currently, COVID-19 vaccines are approved for children aged 12 and older and it is anticipated that younger children will become eligible since pharmaceutical companies are running clinical trials with children to study the safety and efficacy of COVID-19 vaccines (European Medicines Agency, 2021a, 2021b; Health Canada, 2021).

Since parents are key decision-makers for whether their children will receive a COVID-19 vaccine, it is important to measure willingness of parents to vaccinate their children against the COVID-19. Early studies have already investigated parents’ intention to vaccinate their children but until now, no systematic review and meta-analysis on this field is published. Thus, we performed a systematic review and meta-analysis to estimate parents’ willingness to vaccinate their children against the COVID-19, and to investigate the predictors for their decision. Also, we estimated the percentage of the parents that (a) refuse to vaccinate their children against the COVID-19, and (b) were unsure.

2. Methods

2.1. Data sources and strategy

We performed a systematic review and meta-analysis, applying the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher et al., 2009). We searched Scopus, Web of Science, Medline, PubMed, CINAHL and pre-print services (medRxiv) from inception to December 12, 2021. We used the following strategy in all fields: ((vaccin* AND (COVID-19)) AND (parent*). The review protocol was registered with PROSPERO (CRD42021273125).

2.2. Selection and eligibility criteria

Firstly, we removed duplicates, and then we screened consecutively titles, abstracts, and full texts. Also, we examined reference lists of all relevant articles. Two independent researchers performed study selection and a third, senior researcher resolved the discrepancies. We included quantitative studies reporting parents’ willingness to vaccinate their children against the COVID-19. Also, we included quantitative studies that examine factors that affect parents’ willingness to vaccinate their children. Study population included parents and guardians of children aged <18 years. We did not apply criteria regarding study population, e.g. gender, age, race, sample size, etc. We included studies with parents from the general population and excluded studies involving specific population groups (e.g. parents with mental issues or other health issues, specific occupational groups such as physicians, nurses, teachers, etc.). Studies published in English in journals with peer review system were eligible to be included. We excluded protocols, reviews, case reports, opinions articles, commentaries, editorials, and letters to the Editor.

2.3. Data extraction and quality assessment

Two authors independently extracted the following data from the studies: reference, country, data collection time, sample size, gender of parents, age of parents and children, study design, sampling method, recruitment method, response rate, publication type (journal or pre-print), question or statement to measure parents’ willingness, response scales, percentage of parents that agree to vaccinate their children, percentage of parents that refuse to vaccinate their children, percentage of parents that were unsure, and factors that affect parents’ willingness to vaccinate their children.

Studies quality was assessed with the Joanna Briggs Institute critical appraisal tool (Santos et al., 2018). The tool consists of eight questions regarding inclusion criteria for the sample, study settings, exposure and outcome measurement, identification and elimination of confounders, and statistical analysis. There are four answers for each question; e.g., the answers “yes”, “no”, “unclear” and “not applicable” for the question “were strategies to deal with confounding factors stated?”. For this question, when authors use multivariable methods to estimate the relation between an independent variable and the outcome the answer is “yes”, when authors use only univariate methods the answer is “no”, and when the authors do not investigate the relation between an independent variable and the outcome the answer is “not applicable”. Two independent authors rated the quality of the studies and a third senior author solved any discrepancies.

2.4. Statistical analysis

Parents’ intention to vaccinate their children was assessed with a variety of statements or questions like these “When a vaccine for Coronavirus becomes available, I will have my child get it”, “If a COVID-19 vaccine is safe and available to your child for free, how likely would your child be to get vaccinated?” etc. Possible answers were in (a) Likert scales (e.g. strongly disagree; disagree; neither disagree nor agree; agree; strongly agree), (b) yes/no/unsure options, and (c) yes/no/unsure options. For each study, we followed the authors’ decision regarding the positive answer, the negative answer and the unsure answer of parents. For instance, in studies where authors used Likert scales, a positive answer could be only one answer (strongly agree) or two answers (agree and strongly agree). We divided the positive answers of parents by the total number of parents to calculate the proportion of parents that agreed to vaccinate their children. In a similar way, we calculated the proportion of parents that refuse a COVID-19 vaccine for their children, and the proportion of parents that were unsure. Then, we transformed these three proportions with the Freeman-Tukey Double Arcsine method and we calculated the proportion of parents that (a) intend to vaccinate their children against the COVID-19, (b) refuse to vaccinate their children, and (c) were unsure. Moreover, we calculated the 95% confidence intervals (CI) for the proportions (Barendregt et al., 2013).

We used the Hedges Q statistics and I² to assess heterogeneity between studies. A p-value < 0.1 for the Hedges Q statistic indicates statistically significant heterogeneity, while I² value higher than 75% indicates high heterogeneity (Higgins, 2003). We applied a random effect model to estimate pooled effects since the heterogeneity between results was very high (Higgins, 2003). We considered data collection time, age of parents and children, study design, sampling method, recruitment method, response rate, publication type, response scales (studies with or without unsure option), studies quality, and the continent that studies were conducted. Also, we performed meta-regression analysis using data collection time as the independent variable. We treated data collection time as a continuous variable giving the number 1 for studies that were conducted in January 2020, the number 2 for studies that were conducted in
February 2020 etc. We conducted a leave-one-out sensitivity analysis to determine the influence of each study on the overall effect. We used the funnel plot and the Egger's test to assess the publication bias. Regarding the Egger's test, a \( p \)-value < 0.05 indicating publication bias (Egger et al., 1997). We used OpenMeta[Analyst] for the meta-analysis (Wallace et al., 2009).

We did not perform meta-analysis for the factors that influence parents' decision to vaccinate their children against the COVID-19 since the data were highly heterogeneous. Since predictors were measured and/or analyzed differently across studies, we reported the proportion of studies finding positive or negative significant relationships (\( p \)-value < 0.05) between each predictor and parents' intention to vaccinate their children. Thus, we calculated this proportion dividing the number of studies with a significant association (\( p \)-value < 0.05) between the predictor and parents' willingness to vaccinate their children against the COVID-19 by the total number of studies examined the predictor.

3. Results

3.1. Identification and selection of studies

After initial search, we found 6211 unique records. Applying the inclusion and exclusion criteria, we identified 44 articles (Fig. 1).

3.2. Characteristics of the studies

We found 44 studies including 317,055 parents. Details of the studies included in this systematic review are presented in Table 1. Seven studies were conducted in the USA, six studies in China, four studies in Canada, four studies in Israel, four studies in Turkey, four studies in Saudi Arabia, five studies in other European countries (Germany, Greece, Italy, Poland, and United Kingdom), and one study in India, Korea, New Zealand, Qatar, Zambia, Australia, and Brazil. Also, three studies covered more than two countries. Data collection time among studies ranged from March 2020 to September 2021. Sample size ranged from 226 to 227,740 parents with a median number of 1094 parents. The minimum percentage of mothers participating in the studies was 39.6%, while the maximum percentage was 100%. All studies were cross-sectional, while 38 studies used a convenience sample, three studies used a probability sample, one study used a non-probability sample, and two studies used the snowball sampling method. Recruitment of parents was achieved through online surveys in 34 studies, while in 10 studies the study questionnaire was completed during the visit of parents in clinical settings (e.g., pediatric emergency departments, outpatients clinics, primary healthcare centers, etc.). Thirty-eight articles were in peer-reviewed journals and six articles were in pre-print services. Twenty-nine studies included an “unsure” response option for parents' willingness to vaccinate their children, 14 studies did not include this response option, and one study used a scale from 1 to 100 (Table 2).

3.3. Quality assessment

Quality assessment of cross-sectional studies included in this review is shown in Supplementary Table S1. Quality was good in 37 studies, moderate in six studies, and low in one study.

3.4. Parents' willingness and refusal to vaccinate their children

Forty-three studies reported the number of parents that intend to vaccinate their children, while one study measured parents' willingness in a scale from 0 to 100. The overall proportion of parents that intend to vaccinate their children against the COVID-19 was 60.1% (95% CI: 51.7–68.1%) (Fig. 2). The heterogeneity between results was very high (\( I^2 = 99.91\%\), \( p \)-value for the Hedges Q statistic < 0.001). Parents' willingness ranged from 25.6% to 92.2%. A leave-one-out sensitivity analysis showed that no single study had a disproportional effect on the overall proportion, which varied between 59.1% (95% CI: 50.6–67.4%), and 60.9% (95% CI: 52.6–68.9%) (Supplementary Fig. S1). \( p \)-value for Egger's test (<0.05) and funnel plot (Supplementary Fig. S2) indicated potential publication bias.

![Fig. 1. Flowchart of the literature search according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis.](image-url)
Table 1
Overview of the studies included in systematic review.

| Reference       | Country                      | Data collection time | Sample size (n) | Mothers (%)/fathers (%) | Age of parents, mean (SD) | Age of children, mean (SD) | Study design | Sampling method | Recruitment method | Response rate (%) | Published in |
|-----------------|------------------------------|----------------------|-----------------|-------------------------|---------------------------|---------------------------|--------------|------------------|------------------|------------------|--------------|
| (Ruggiero et al., 2021) | USA                          | November 2020 to January 2021 | 427             | NR                      | NR                        | <3 years, 23.1%         | Cross-sectional | Snowball         | Online survey     | NR               | Journal      |
| (Wang et al., 2021a) | China                        | September 21 to October 17, 2020 | 3009            | 74.6/25.4              | 31.4 (4.5)                | 2.2 (2.4)                  | Cross-sectional | Convenience      | Community health service center immunization clinics | 87 Journal      |
| (Szlajgyi et al., 2021) | USA                          | February 17 to March 30, 2021 | 1745            | 57.9/42.1              | 18–39 years, 22.3%       | <5 years, 21.8%          | Cross-sectional | Probability      | Online survey     | NR               | Journal      |
| (Montalti et al., 2021) | Italy                        | December 2020 to January 2021 | 4993            | 76.6/23.4              | ≤29 years, 1.8%          | ≤5 years, 12.7%          | Cross-sectional | Probability      | Online survey     | NR               | Journal      |
| (Gelty et al., 2021)   | USA                          | April 2020            | 2279            | 52/48                   | ≤34 years, 2%            | NR                        | Cross-sectional | Probability      | National community online survey | NR               | Journal      |
| (Bell et al., 2020a)   | United Kingdom               | April 19 to May 11, 2020 | 1252            | 95/5                    | 32.9 (4.6)               | ≤14 months, 86.9%        | Cross-sectional | Probability      | Online survey     | NR               | Journal      |
| (Xu et al., 2021c)     | China                        | December 2020         | 4748            | 76/24                   | 40.2 (5.1)               | <10 years, 27.9%         | Cross-sectional | Probability      | Online survey     | NR               | Journal      |
| (Brandstetter et al., 2021) | Germany                     | May 2020              | 612             | 80/10 (10 mothers and fathers) | 34.4 (7.3)               | ≤6 years, 14.6%          | Cross-sectional | Probability      | Online survey     | 50.1             | Journal      |
| (Skjefte et al., 2021) | USA                           | October 28 to November 18, 2020 | 17,054         | 100/0                   | 34.7 (7.3)               | ≤6 years, 14.6%          | Cross-sectional | Probability      | Online survey     | NR               | Journal      |
| (Goldman et al., 2020) | USA, Canada, Spain, Israel, Japan, and Switzerland | March 26 to May 31, 2020 | 1541           | 72/25.5 (2.5 other)    | 39.9 (7.6)               | 7.5 (5.0)                  | Cross-sectional | Probability      | Pediatric emergency departments Online survey | NR               | Journal      |
| (Hetherington et al., 2021) | Canada                      | May to June 2020      | 1321            | 42.2 (4.4)             | NR                        | ≤6 years, 49.8%          | Cross-sectional | Probability      | Community online survey | 53.8             | Journal      |
| (Yigit et al., 2021)   | Turkey                       | NR                    | 428             | 63.6/36.4              | 39.7 (10.7)              | ≤6 years, 49.8%          | Cross-sectional | Probability      | Community online survey | NR               | Journal      |
| (Yilmaz and Sahin, 2021) | Turkey                       | February 2021         | 1035            | 77.8/22.2              | ≤29 years, 12.6%         | ≤6 years, 49.8%          | Cross-sectional | Probability      | Community online survey | NR               | Journal      |
| (Teandale et al., 2021) | USA                          | March 2021            | 2074            | 60.1/39.3 (0.6 others) | 4.7 (1.7–8.3)            | ≤29 years, 20.3%         | Cross-sectional | Community online survey | NR               | Journal      |
| (Jeffs et al., 2021)   | New Zealand                  | May 2020              | 1191            | 92.7/6.2 (1.2 caregivers) | 39.9 (NR)               | ≤6 years, 49.8%          | Cross-sectional | Probability      | Online survey     | NR               | Journal      |
| (Scherer et al., 2021) | USA                          | April 2021            | 1022            | 48.2/51.3 (0.5 others) | NR                        | ≤6 years, 23.6%          | Cross-sectional | Probability      | Online survey     | 77.5             | Journal      |

(continued on next page)
Table 1 (continued)

| Reference                  | Country            | Data collection time | Sample size (n) | Mothers (%)/fathers (%) | Age of parents, mean (SD) | Age of children, mean (SD) | Study design          | Sampling method     | Recruitment method | Response rate (%) | Published in     |
|----------------------------|--------------------|----------------------|-----------------|-------------------------|---------------------------|---------------------------|----------------------|-------------------|-------------------|-------------------|-------------------|
| (Zhang et al., 2020)       | China              | September 2020       | 1052            | 62.5/37.5               | ≤16 years, 62%; ≥16 years, 38% | ≤15 years, 22.6%; 31–40 years, 55.7%; >41 years, 21.7% | Cross-sectional | Convenience     | Online survey | NR                | Journal           |
| (Akarsu et al., 2021)      | Turkey             | June to July 2020    | 232             | 62.8/37.2               | ≤6 months, 12.4%; 6–18 months, 18.2%; >18 months, 69.4% | 32.4 (9.9)                     | Cross-sectional | Cross-sectional | Non-probability purposive | Online survey | NR                | Journal           |
| (Aldakhil et al., 2021)    | Saudi Arabia       | January to February 2021 | 280   | 100/0                  | NR                        | 33 (5.5)                      | Cross-sectional | Cross-sectional | Online survey | NR                | Journal           |
| (Aldakhil et al., 2021)    | Saudi Arabia       | May to June 2021     | 1000            | 78.8/21.2               | 0–2 years, 40.2%; 2–6 years, 40.2%; >6 years, 35.2% | <6 months, 41.4%; 7–17 years, 58.6% | Cross-sectional | Cross-sectional | Probability purposive | Online survey | 38.4              | Journal           |
| (Alifri et al., 2021)      | USA                | June 2020            | 1425            | NR                      | 2 years, 16.6%; ≥2 years, 83.4% | <2 years, 34.5%; ≥40 years, 55.5%; >40 years, 25.3% | Cross-sectional | Convenience | Online survey | NR                | Journal           |
| (Almashah et al., 2021)    | Saudi Arabia       | May to June 2021     | 501             | 85/15                   | 18–29 years, 13%; ≥30 years, 87% | 18–30 years, 29.1%; 31–40 years, 45.6%; >40 years, 25.3% | Cross-sectional | Cross-sectional | Convenience | Primary healthcare centers | 83.3             | Journal           |
| (Osibicki et al., 2021)    | Poland             | May 2021             | 4432            | 77.6/22.4               | <6 months, 12.4%; 6–18 months, 18.2% | <6 months, 12.4%; 6–18 months, 18.2%; >18 months, 69.4% | Cross-sectional | Convenience | Online survey | NR                | Journal           |
| (Bagatei et al., 2021)     | Brazil             | May to June 2021     | 501             | 85/15                   | 18–29 years, 13%; ≥30 years, 87% | 18–29 years, 13%; ≥30 years, 87% | Cross-sectional | Cross-sectional | Convenience | Pediatric emergency departments | 100              | Journal           |
| (Carcelen et al., 2021)    | Zambia             | November 2020        | 2400            | NR                      | 18–29 years, 13%; ≥30 years, 87% | 18–29 years, 13%; ≥30 years, 87% | Cross-sectional | Cross-sectional | Convenience | Primary healthcare centers | NR                | Journal           |
| (Choi et al., 2021)        | Korea              | May to June 2021     | 226             | 79.6/20.4               | <39 years, 34.5%; ≥40 years, 65.5% | 10–15 years, 84.6%; 16–18 years, 15.4% | Cross-sectional | Cross-sectional | Convenience | Outpatients clinics | NR                | Journal           |
| (Dror et al., 2020)        | Israel             | March 2020           | 1112            | NR                      | NR                         | NR                         | Cross-sectional | Convenience | Online survey | NR                | Journal           |
| (Evans et al., 2021)       | Australia          | January 2021         | 1094            | 83/17                   | NR                         | NR                         | Cross-sectional | Convenience | Online survey | NR                | Journal           |
| (Gendler and Ofri, 2021)   | Israel             | June 2021            | 520             | 77.1/22.9               | NR                         | NR                         | Cross-sectional | Convenience | Online survey | NR                | Journal           |
| (Humble et al., 2021)      | Canada             | December 2020        | 1702            | 55.3/44                 | <12 years, 66.4%; ≥12 33.6% | 10–15 years, 84.6%; 16–18 years, 15.4% | Cross-sectional | Cross-sectional | Convenience | Online survey | NR                | Journal           |
| (Kehong et al., 2021)      | China              | July 2020            | 13,451          | 63.6/36.4               | NR                         | NR                         | Cross-sectional | Convenience | Online survey | NR                | Journal           |
| (Lackner and Wang, 2021)   | Canada             | July 2020            | 455             | 91.9/7.3                | NR                       | NR                         | Cross-sectional | Convenience | Online survey | NR                | Journal           |
| (Musa et al., 2021)        | Qatar              | May to June 2021     | 4023            | NR                      | NR                         | NR                         | Cross-sectional | Convenience | Outpatients clinics | Online survey | NR                | Journal           |
| (Temsah et al., 2021)      | Saudi Arabia       | NR                  | 3167            | 65/35                   | 18–44 years, 62.7%; ≥45 years, 37.3% | 10–15 years, 84.6%; 16–18 years, 15.4% | Cross-sectional | Cross-sectional | Convenience | Online survey | NR                | Journal           |
| (Urunagana-Pastor et al., 2021) | 20 Latin America and Caribbean countries | May to July 2021 | 227,740 | 55/45                 | 18–34 years, 41.3%; ≥35 years, 58.7% | 37.0 (5.9)                | Cross-sectional | Convenience | Online survey | NR                | Journal           |
| (Yu et al., 2021)          | China              | July to August 2021  | 917             | 67.5/32.5               | NR                         | NR                         | Cross-sectional | Convenience | Online survey | NR                | Journal           |
| (Yilmazbag et al., 2021)   | Turkey             | May 2020             | 440             | 70.5/29.5               | NR                         | NR                         | Cross-sectional | Convenience | Online survey | NR                | Journal           |
| (Zhou et al., 2021)        | China              | July to September 2020 | 747   | 75.5/24.5              | <40 years, 82.6%; ≥40 years, 17.4% | <6 months, 12.4%; 6–18 months, 18.2%; >18 months, 69.4% | Cross-sectional | Cross-sectional | Convenience | Online survey | NR                | Journal           |
| (Galantis et al., 2021)    | Greece             | September 2020       | 813             | 76.1/23.9               | 42.3 (7.4)                | NR                         | Cross-sectional | Cross-sectional | Convenience | Online survey | NR                | Pre-print         |
| (Atad et al., 2021)        | Israel             | April to May 2021    | 1118            | NR                      | NR                         | NR                         | Cross-sectional | Cross-sectional | Convenience | Online survey | NR                | Pre-print         |
| (USA)                      | USA                | June 2020            | 1008            | NR                      | NR                         | NR                         | Cross-sectional | Convenience | Online survey | 50                | Pre-print         |
Table 1 (continued)

| Reference                          | Country          | Data collection time                  | Sample size (n) | Mothers (%)/fathers (%) | Age of parents, mean (SD) | Age of children, mean (SD) | Study design | Sampling method | Recruitment method | Response rate (%) | Published in  |
|------------------------------------|------------------|--------------------------------------|----------------|-------------------------|---------------------------|---------------------------|--------------|-----------------|-------------------|------------------|--------------|
| (Davis et al., 2020)               | India            | November 2020 to January 2021        | 770            | 39.6/60.4               | 18–49 years, 75.6%, ≥50 years, 24.4% | NR                        | Cross-sectional | Cross-sectional | Convenience                | Online survey     | NR           | Pre-print |
| (Padhi et al., 2021)               |                  |                                      | 809            | NR                      | NR                        | NR                        | Cross-sectional | Convenience | Online survey     | NR               | Pre-print |
| (McKinnon et al., 2021)            |                  |                                      | 1012           | 51/49                   | 18–39 years, ≥40 years, 51.7% | NR                        | Cross-sectional | Convenience | Online survey     | NR               | Pre-print |
| (Pritchard, 2021)                  |                  |                                      |                |                         |                           |                           |              |                 |                   |                  |              |
| (Scherer et al., 2021)             |                  |                                      |                |                         |                           |                           |              |                 |                   |                  |              |
| (Zhang et al., 2020)               |                  |                                      |                |                         |                           |                           |              |                 |                   |                  |              |
| (Akarsu et al., 2021)              |                  |                                      |                |                         |                           |                           |              |                 |                   |                  |              |
| (Tsurumi, 2021)                    |                  |                                      |                |                         |                           |                           |              |                 |                   |                  |              |

NR: not reported.

* Median (standard deviation).

b Median (interquartile range).

Table 2
Response scales and results of parents’ willingness to vaccinate their children against the COVID-19 in studies included in systematic review.

| Reference                          | Question/statement to measure parents’ willingness                                                                 | Response scale | Willingness results (%) |
|------------------------------------|-------------------------------------------------------------------------------------------------------------------|----------------|-------------------------|
| (Ruggiero et al., 2021)            | I plan to have my child vaccinated with a COVID-19 vaccine if one becomes available                                   | Yes [Y], no [N]| Yes: 44.3               |
| (Brandstetter et al., 2021)        | If a COVID-19 vaccine is available, will you vaccinate for your child?                                            | Yes [Y], unsure [U], no [N] | No: 55.7               |
| (Skjefte et al., 2021)             | How likely are you to get your child vaccinated for coronavirus once a vaccine is available for children?            | Very likely [Y], somewhat likely [Y], unsure [N], somewhat unlikely [N], very unlikely [N] | Yes: 48               |
| (Goldman et al., 2020)             | If a new COVID-19 vaccine became available would you accept the vaccine for your child/children?                    | Yes [Y], unsure [U], no [N] | No: 52                 |
| (Health et al., 2021)              | At this moment, are you willing to receive COVID-19 vaccination for your child?                                       | Yes [Y], unsure [U], no [N] | No: 59.0               |
| (Vigli et al., 2021)               | Would you vaccinate your child if a COVID-19 vaccine is available?                                                    | Yes [Y], no [N] | Yes: 27                |
| (Yilmaz and Sahin, 2021)           | If an approved COVID-19 vaccine becomes available, would you have your child vaccinated?                             | Yes [Y], unsure [U], no [N] | No: 27                 |
| (Jepp et al., 2021)                | If a new approved COVID-19 vaccine became available would you plan to have your child receive this vaccine?         | Yes [Y], unsure [U], no [N] | Yes: 51                |
| (Scherer et al., 2021)             | Would you vaccinate your child if a COVID-19 vaccine is available?                                                    | Yes [Y], no [N] | Yes: 30.8              |
| (Zhang et al., 2020)               | If a COVID-19 vaccine is safe and available to your child for free, how likely would your child be to get vaccinated? | Very likely [Y], likely [Y], neutral [U], unlikely [N], very unlikely [N] | Yes: 72.6               |
| (Akarsu et al., 2021)              | If an approved COVID-19 vaccine becomes available, would you plan to have your child receive this vaccine?         | Yes [Y], unsure [U], no [N] | Yes: 55.5              |

(continued on next page)
| Reference | Question/statement to measure parents’ willingness | Response scale | Willingness results (%) |
|-----------|-----------------------------------------------|----------------|-------------------------|
| Aldakhil et al., 2021 | It is likely that I will vaccinate my child/children against COVID-19 in the next 6 months | Strongly agree [Y], agree [Y], neutral [U], disagree [N], strongly disagree [N] | Yes: 52.5  Unsure: 27.9  No: 19.6 |
| Alifiari et al., 2021 | If a new vaccine against COVID-19 became available, how likely would you be to get your child vaccinated? | Very likely [Y], somewhat likely [Y], I’m not sure [U], not likely [N] | Yes: 33.0  Unsure: NR  No: NR |
| Almushah et al., 2021 | Are you willing to get the COVID-19 vaccine for your child if approved? | Yes [Y], unsure [U], no [N] | Yes: 25.6  Unsure: 37.0  No: 37.4 |
| Aalolabi et al., 2021 | If a COVID-19 vaccine is available, will you vaccinate for your child? | Very likely [Y], likely [Y], neutral [U], unlikely [N], very unlikely [N] | No: 27.0 |
| Babicki et al., 2021 | Are you planning to vaccinate your child against COVID-19? | Yes, as soon as it will be possible [Y], yes, but only in a few months (up to a year) [Y], yes, but in more than a year [N], I cannot decide [U], no, but maybe I will consider it in the future [N], no, never [N] | Yes: 44.1  Unsure: 11.3  No: 44.6 |
| Bagateli et al., 2021 | Would you have your child vaccinated with a vaccine reported effective against COVID-19 and approved by the authorities? | Yes [Y], unsure [U], no [N] | Yes: 91  Unsure: 4.6 |
| Cancelen et al., 2021 | If a COVID-19 vaccine is available, will you vaccinate your child? | Yes [Y], unsure [U], no [N] | Yes: 92  Unsure: NR  No: 4.4 |
| Choi et al., 2021 | If a vaccine against COVID-19 is available, how likely would you be to get your children vaccinated? | Extremely likely [Y], somewhat likely [Y], neither likely nor unlikely [U], somewhat unlikely [N], extremely unlikely [N] | Yes: 64.2  Unsure: 23.5  No: 12.3 |
| Doror et al., 2020 | Would you vaccinate your child for COVID-19? | Yes [Y], unsure [U], no [N] | Yes: 70  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR |
| Evans et al., 2021 | If a COVID-19 vaccine is available, will you vaccinate for your child? | Yes [Y], unsure [U], no [N] | Yes: 48  Unsure: 38  No: 14  Yes: 70.4  Unsure: 29.6 |
| Gendler and Ofrí, 2021 | If a vaccine against COVID-19 is available, how likely would you be to get your children vaccinated? | Very likely [Y], somewhat likely [Y], somewhat unlikely [N], definitely not [N] | Yes: 63.1  Unsure: NR  No: NR  Yes: 50.0  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR |
| Humble et al., 2021 | If a safe and effective COVID-19 vaccine is available, I will get my child/children vaccinated | Strongly agree [Y], agree [Y], neutral [U], disagree [N], strongly disagree [N] | Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR |
| Kezhong et al., 2021 | If a COVID-19 vaccine is available, will you vaccinate for your child? | Yes [Y], unsure [U], no [N] | Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR |
| Lackner and Wang, 2021 | If a vaccine against COVID-19 is available, how likely would you be to get your children vaccinated? | A scale from 1 to 100 | Yes: 55.0  Unsure: 1.6  No: 1.6  Yes: 85.3  Unsure: 14.7  No: 14.7 |
| Musa et al., 2021 | Parents’ agreement to obtain a confirmed COVID-19 vaccine booking appointment for their children at the time of study | Yes [Y], no [N] | Yes: 82.1  Unsure: 17.9  No: 17.9  Yes: 47.5  Unsure: 20.5  No: 20.5 |
| Temsah et al., 2021 | Are you willing/intending to give the COVID-19 vaccine to your child (children)? | Yes [Y], unsure [U], no [N] | Yes: 92.2  Unsure: 7.8  No: 7.8  Yes: 84.3  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR |
| Urrunaga-Pastor et al., 2021 | Will you choose to get a COVID-19 vaccine for your child if children when they are eligible? | Yes, definitely [Y], yes, probably [Y], no, probably not [N], no, definitely not [N] | Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR |
| Xu et al., 2021b | If a COVID-19 vaccine is available for children, would you like them to get it? | Yes [Y], unsure [U], no [N] | Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR |
| Yılmazbaş et al., 2021 | If a vaccine is reported to be effective against COVID-19, would you consider getting it to your children? | I definitely do [Y], I’ll probably get it [U], undecided [U], I definitely not [N] | Yes: 43.4  Unsure: 55.0  No: 1.6  Yes: 85.3  Unsure: 14.7  No: 14.7 |
| Zhou et al., 2021 | If a COVID-19 vaccine is available, will you vaccinate your child? | Yes [Y], no [N] | Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR |
| Galanis et al., 2021b | If a COVID-19 vaccine is available, will you vaccinate your child? | Yes [Y], unsure [U], no [N] | Yes: 36.0  Unsure: 30.5  No: 33.5  Yes: 31.5  Unsure: 68.5  No: 68.5 |
| Atad et al., 2021 | Do you intend to vaccinate your children when the COVID-19 vaccine becomes available for them? | Yes, definitely [Y], yes, probably [N], undecided [N], no, probably not [N], no, definitely not [N] | Yes: 31.5  Unsure: 68.5  No: 68.5  Yes: 63.0  Unsure: 37.0  No: 37.0  Yes: 74.0  Unsure: 14.0  No: 14.0  |
| Davis et al., 2020 | If a vaccine against COVID-19 becomes available in the next 12 months, how likely are you to get it for your child(ren)? | Very likely [Y], somewhat likely [Y], not too likely [N], not at all likely [N] | Yes: 73.3  Unsure: 14.3  No: 12.4  Yes: 57.2  Unsure: NR  No: NR |
| Padhi et al., 2021 | Do you intend to vaccinate your child(ren) for COVID-19 once a vaccine is available for children? | Yes [Y], unsure [U], no [N] | Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR |
| Mckinnon et al., 2021 | If a COVID-19 vaccine is available, will you vaccinate your child? | Very likely [Y], somewhat likely [U], unlikely [N] | Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR  Yes: NR  Unsure: NR  No: NR |
| Shmuei, 2021 | How appropriate do you consider to vaccinate your children against COVID-19? | A scale from 1 [not appropriate at all] to 6 [very appropriate, Y] | Yes: 57.2  Unsure: NR  No: NR  |

NR: not reported.

* [Y], [N] and [U] indicate extracted response options representing yes, no and unsure in this meta-analysis.
Thirty-four studies reported data on parents' refusal to vaccinate their children. The pooled proportion of parents that refuse to vaccinate their children was 22.9% (95% CI: 17.3–29.0%) (Fig. 3). The heterogeneity between results was very high ($I^2 = 99.83\%$, $p$-value for the Hedges Q statistic $< 0.001$). Parents' refusal ranged from 1.6% to 71.0%. A leave-one-out sensitivity analysis showed that no single study had a disproportional effect on the overall proportion, which varied between 21.6% (95% CI: 16.2–27.6%) and 23.9% (95% CI: 18.1–30.1%) (Supplementary Fig. S3). $p$-value for Egger's test ($< 0.05$) and funnel plot (Supplementary Fig. S4) indicated potential publication bias.

Twenty-one studies presented the number of parents reporting uncertainty of their children's vaccination against the COVID-19. The pooled proportion of unsure parents was 25.8% (95% CI: 20.0–32.0%) (Fig. 4). The heterogeneity between results was very high ($I^2 = 99.36\%$, $p$-value for the Hedges Q statistic $< 0.001$). Proportion of unsure parents ranged from 4.6% to 55.0%. A leave-one-out sensitivity analysis showed that no single study had a disproportional effect on the overall proportion, which varied between 24.5% (95% CI: 16.2–30.6%) and 27.2% (95% CI: 18.1–30.1%) (Supplementary Fig. S3). $p$-value for Egger's test ($< 0.05$) and funnel plot (Supplementary Fig. S4) indicated potential publication bias.

### 3.5. Presence vs. absence of an “unsure” response option

When “unsure” was a response option for the parents the overall proportion of parents that intend to vaccinate their children was lower (58.3%, 95% CI = 52.7–63.8%, $I^2 = 99.45\%$) than in studies where there was no “unsure” response option (64.5%, 95% CI = 51.6–76.5%, $I^2 = 99.91\%$). Difference was larger in case of parents' refusal to vaccinate their children. In particular, when there was the “unsure” response option the pooled proportion of parents that refuse to vaccinate their children was 16.9% (95% CI = 11.1–23.6%, $I^2 = 99.60\%$), and when “unsure” was not a response option the proportion was 35.5% (95% CI = 23.5–48.4%, $I^2 = 99.91\%$).

### 3.6. Time trends

Meta-regression analysis showed that parents' willingness to vaccinate their children against the COVID-19 was independent of the data collection time (coefficient $= 0.003$, 95% CI = −0.014 to 0.008, $p = 0.63$) (Supplementary Fig. S7). Similarly, there was not a relation between month study was conducted (coefficient $= 0.008$, 95% CI = −0.007 to 0.022, $p = 0.32$) (Supplementary Fig. S8). Moreover, there was no relation between proportion of parents being unsure about their children's vaccination and month of study.
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(coefficient = 0.009, 95% CI = 0.024 to 0.006, p = 0.24) (Supplementary Fig. S9).

Also, we analyzed the time trend separately for studies with an “unsure” response option and those without this response option and we confirmed that data collection time did not affect parents’ intentions. Specifically, there was not a relation between intention of parents to vaccinate their children and data collection time in studies with an “unsure” response option (coefficient = 0.003, 95% CI = 0.015 to
Table 3
Studies examining factors related with parents’ willingness to vaccinate their children against the COVID-19.

(a)

| Reference | Older children | Older parents | Fathers | Higher educational level | Ethnicity | Higher income | Health insurance | Increased number of children | Children with chronic illness | Higher risk perception of getting infected | Increased perceived threat from the COVID-19 | Psychological distress | Trust in public health agencies/health science/physicians |
|-----------|----------------|---------------|---------|--------------------------|-----------|---------------|-------------------|-----------------------------|---------------------------------|---------------------------------|-----------------------------|--------------------------|------------------------------------------------|
| (Ruggiero et al., 2021) | – | – | – | – | – | – | – | ↑ | – | – | – | – | – |
| (Wang et al., 2021a) | – | NS | NS | ↓ | – | NS | – | – | – | – | – | – | – |
| (Szilagyi et al., 2021) | ↑ | – | NS | ↑ | NS | – | – | – | – | – | – | – | – |
| (Montalti et al., 2021) | – | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| (Kelly et al., 2021) | – | NS | ↑ | ↑ | ↓ | – | NS | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| (Bell et al., 2020a) | – | NS | – | – | ↓ | – | NS | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| (Xu et al., 2021c) | – | – | – | – | – | – | – | – | – | – | – | – | – |
| (Brandstetter et al., 2021) | – | NS | – | ↑ | NS | – | – | – | – | NS | NS | – | – |
| (Shijie et al., 2021) | ↑ | – | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| (Goldman et al., 2020) | – | NS | – | ↑ | NS | – | – | – | – | ↑ | ↑ | ↑ | ↑ |
| (Hetherington et al., 2021) | – | NS | – | ↑ | NS | ↑ | – | – | – | – | – | – | – |
| (Vigil et al., 2021) | – | NS | ↑ | ↓ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| (Yılmaz and Sahin, 2021) | – | NS | – | ↑ | NS | – | – | – | – | ↑ | ↑ | ↑ | ↑ |
| (Frascarelli et al., 2021) | – | NS | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| (Scherer et al., 2021) | – | NS | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| (Zhang et al., 2020) | – | – | – | – | – | – | – | – | – | – | – | – | – |
| (Akarsu et al., 2021) | – | NS | NS | ↑ | – | NS | ↑ | – | NS | – | – | NS | – |
| (Aldahkhil et al., 2021) | NS | NS | – | ↑ | – | – | – | NS | – | – | – | – | – |
| (Alfieri et al., 2021) | – | – | – | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| (Almasnab et al., 2021) | NS | – | ↑ | – | – | – | – | NS | – | – | – | – | – |
| (Altalab et al., 2021) | ↑ | ↑ | NS | NS | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| (Babicki et al., 2021) | NS | ↑ | NS | – | – | – | – | NS | NS | – | ↑ | ↑ | ↑ |
| (Bagatelli et al., 2021) | NS | ↑ | NS | ↑ | NS | ↑ | – | ↓ | – | – | – | – | – |

(continued on next page)
Table 3 (continued)

(a) Reference	Older children	Older parents	Fathers	Higher educational level	Ethnicity	Higher income	Health insurance	Increased number of children	Children with chronic illness	Higher risk perception of getting infected	Increased perceived threat from the COVID-19	Psychological distress

| Reference                        | Older children | Older parents | Fathers | Higher educational level | Ethnicity | Higher income | Health insurance | Increased number of children | Children with chronic illness | Higher risk perception of getting infected | Increased perceived threat from the COVID-19 | Psychological distress |
|---------------------------------|----------------|---------------|---------|--------------------------|-----------|----------------|------------------|-----------------------------|-----------------------------|------------------------------------------|---------------------------------------------|------------------------|
| (Choi et al., 2021)             | –              | –             | NS      | NS                       | NS        | NS             | –                | NS                         | –                           | –                                        | –                                        | NS NS ↑ ↑ ↑ |
| (Evans et al., 2021)            | –              | NS            | NS      | NS                       | NS        | NS             | –                | NS                         | –                           | –                                        | –                                        | – NS – – |
| (Humble et al., 2021)           | ↓              | NS            | –       | ↓                        | NS        | NS             | –                | NS                         | –                           | –                                        | –                                        | – – – – |
| (Koolhong et al., 2021)         | NS             | ↓             | NS      | NS                       | NS        | NS             | –                | NS                         | –                           | –                                        | –                                        | – – – – |
| (Lackner and Wang, 2021)        | NS             | ↑             | NS      | ↓                        | NS        | ↓              | ↑                | NS                         | ↓                           | –                                        | NS –                                  | – – – – |
| (Musa et al., 2021)             | ↓              | –             | –       | –                        | –         | –              | –                | –                          | –                           | –                                        | –                                        | – – – – |
| (Temsah et al., 2021)           | ↑ ↑            | –             | NS      | ↑                        | ↑         | ↑              | ↑                | ↑                          | ↑                           | ↑ – ↑ ↑                                  | ↑ – ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ |
| (Urrunaga-Pastor et al., 2021)  | NS             | ↑             | NS      | ↑                        | ↑         | ↑              | ↑                | ↑                          | ↑                           | ↑ – ↑ ↑                                  | ↑ – ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ |
| (Xu et al., 2021)               | NS             | NS            | NS      | ↓                        | –         | ↑              | –                | –                          | –                           | – – – – – – – – – – – – – – – – – – – – – |
| (Zhou et al., 2021)             | NS             | NS            | NS      | ↓                        | –         | –              | –                | NS                         | –                           | –                                        | –                                        | – – – – |
| (Galanis et al., 2021)          | –              | ↑             | NS      | NS                       | NS        | ↑              | ↑                | NS                         | ↑                           | ↑                                       | ↑                                       | ↑ – ↑ |
| (Atad et al., 2021)             | –              | –             | –       | ↑                        | –         | ↑              | ↑                | ↑                          | ↑                           | ↑                                       | ↑ – ↑ ↑ ↑ ↑ ↑ ↑ ↑ |
| (Davis et al., 2020)            | –              | ↑             | NS      | ↑                        | ↑ (Hispanic parents) | ↑ (Hispanic parents) | ↑ (Hispanic parents) | ↑ (Hispanic parents) | ↑ (Hispanic parents) | ↑ (Hispanic parents) | ↑ (Hispanic parents) | ↑ (Hispanic parents) |
| (Padhi et al., 2021)            | NS             | NS            | NS      | ↑                        | ↑ (White parents) | ↑ (White parents) | ↑ (White parents) | ↑ (White parents) | ↑ (White parents) | ↑ (White parents) | ↑ (White parents) | ↑ (White parents) |
| (Mckinnon et al., 2021)         | NS             | NS            | NS      | –                        | ↑ (White parents) | ↑ (White parents) | ↑ (White parents) | ↑ (White parents) | ↑ (White parents) | ↑ (White parents) | ↑ (White parents) | ↑ (White parents) |
| (Shmueli, 2021)                 | –              | ↑             | 4/16    | 10/25                    | 7/24       | 15/29          | 3/25             | 10/25                      | 7/24                        | 1/4                       | 3/11                      | 1/10                      | 2/6                      | 4/6                      | 1/6                      | 3/5                      |

(b) Reference	Children’s complete vaccination history	History of children’s vaccination against influenza	History of parents’ vaccination against influenza	Confidence in vaccines	Confidence in COVID-19 vaccines	Vaccination hesitancy	Concerns for serious side effects and effectiveness of COVID-19 vaccines	COVID-19 vaccine uptake/intention among parents	Information based in the web/social media	Compliance with prevention measures/knowledge about prevention measures	High level of information about the COVID-19 pandemic/vaccination	Level of analysis

| Reference                      | Children’s complete vaccination history | History of children’s vaccination against influenza | History of parents’ vaccination against influenza | Confidence in vaccines | Confidence in COVID-19 vaccines | Vaccination hesitancy | Concerns for serious side effects and effectiveness of COVID-19 vaccines | COVID-19 vaccine uptake/intention among parents | Information based in the web/social media | Compliance with prevention measures/knowledge about prevention measures | High level of information about the COVID-19 pandemic/vaccination | Level of analysis |
|--------------------------------|----------------------------------------|---------------------------------------------------|-------------------------------------------------|------------------------|-------------------------------|----------------------|------------------------------------------------------------------------|-----------------------------------------------|-----------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------|---------------|
| Positive association\(\text{a}\) | 4/16                                   | 10/25                                              | 7/24                                            | 15/29                  | 3/12 (White \[n = 1\], Asian \[n = 1\], and Hispanic \[n = 1\] parents) | 7/20                 | 1/4                                                                | 3/11                           | 1/10                           | 2/6                                                                | 4/6                           | 1/6                      | 3/5                      |
| Negative association\(\text{b}\) | 2/16                                   | 0/25                                               | 0/24                                            | 6/29                   | 4/12 (Black \[n = 4\] and Asian \[n = 1\] parents) | 2/20                 | 0/4                                                                | 1/11                           | 1/10                           | 0/6                                                                | 0/6                           | 2/6                      | 0/5                      |
| No association\(\text{c}\)      | 10/16                                  | 15/25                                              | 17/24                                           | 8/29                   | 5/12                          | 11/20                | 3/4                                                                | 7/11                           | 8/10                           | 4/6                                                                | 2/6                           | 3/6                      | 2/5                      |
| Reference                                      | Children’s complete vaccination history | History of children’s vaccination against influenza | History of parents’ vaccination against influenza | Confidence in vaccines | Confidence in COVID-19 vaccines | Vaccination hesitancy | Concerns for serious side effects and effectiveness of COVID-19 vaccines | COVID-19 vaccine uptake/intention among parents | Information based in the web/social media | Compliance with prevention measures/knowledge about prevention measures | High level of information about the COVID-19 pandemic/vaccination | Level of analysis |
|------------------------------------------------|-----------------------------------------|-----------------------------------------------|-----------------------------------------------|----------------------|---------------------------------|----------------------|---------------------------------------------------------------------|-----------------------------------------------|-----------------------------------------------|------------------------------------------------------------------|-------------------------------------------------|-----------------|
| (Ruggiero et al., 2021)                         | –                                       | ↑                                             | –                                             | ↑                   | ↓                              | ↓                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Wang et al., 2021a)                            | –                                       | –                                             | –                                             | –                   | –                              | –                    | ↑                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Salagyi et al., 2021)                          | –                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | ↑                                                | –                  | Multivariable |
| (Montali et al., 2021)                          | –                                       | –                                             | –                                             | –                   | –                              | –                    | ↓                                                                  | –                                             | ↓                                             | –                                                | –                  | Multivariable |
| (Kelly et al., 2021)                            | –                                       | –                                             | ↑                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Bell et al., 2020a)                            | –                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | Multivariable |
| (Xu et al., 2021c)                              | –                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | Multivariable |
| (Brandstetter et al., 2021)                     | ↑                                       | –                                             | –                                             | ↑                   | ↑                              | ↑                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Univariate  |
| (Skjefte et al., 2021)                          | ↑                                       | ↑                                             | ↑                                             | ↑                   | ↑                              | ↑                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Goldman et al., 2020)                          | ↑                                       | ↑                                             | ↑                                             | ↑                   | ↑                              | ↑                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Univariate  |
| (Hetherington et al., 2021)                     | ↑                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Yigit et al., 2021)                            | –                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Univariate  |
| (Yilmaz and Sahin, 2021)                        | –                                       | –                                             | –                                             | ↑                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Teasdale et al., 2021)                         | –                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Scherer et al., 2021)                          | –                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Zhang et al., 2020)                            | –                                       | –                                             | –                                             | ↑                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Akaru et al., 2021)                            | NS                                      | –                                             | ↑                                             | –                   | ↑                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Univariate  |
| (Aldahili et al., 2021)                         | –                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Alifer et al., 2021)                           | –                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Almutbaha et al., 2021)                        | NS                                      | –                                             | ↑                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Univariate  |
| (Almutbaha et al., 2021)                        | NS                                      | –                                             | ↑                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | NS                 | Multivariable |
| (Almutbaha et al., 2021)                        | NS                                      | –                                             | ↑                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | NS                 | Multivariable |
| (Babicki et al., 2021)                          | ↑                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Bagatelli et al., 2021)                        | ↑                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Univariate  |
| (Choi et al., 2021)                             | ↑                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Teasdale et al., 2021)                         | ↑                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Scherer et al., 2021)                          | ↑                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Zhang et al., 2020)                            | –                                       | –                                             | –                                             | ↑                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | ↑                  | Multivariable |
| (Akaru et al., 2021)                            | NS                                      | –                                             | ↑                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Univariate  |
| (Aldahili et al., 2021)                         | –                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Alifer et al., 2021)                           | –                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Almutbaha et al., 2021)                        | NS                                      | –                                             | ↑                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Univariate  |
| (Almutbaha et al., 2021)                        | NS                                      | –                                             | ↑                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | NS                 | Multivariable |
| (Almutbaha et al., 2021)                        | NS                                      | –                                             | ↑                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | NS                 | Multivariable |
| (Babicki et al., 2021)                          | ↑                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Bagatelli et al., 2021)                        | ↑                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Univariate  |
| (Choi et al., 2021)                             | ↑                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Teasdale et al., 2021)                         | ↑                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Scherer et al., 2021)                          | ↑                                       | –                                             | –                                             | –                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | –                  | Multivariable |
| (Zhang et al., 2020)                            | –                                       | –                                             | –                                             | ↑                   | –                              | –                    | –                                                                  | –                                             | –                                             | –                                                | ↑                  | Multivariable |

(continued on next page)
Table 3 (continued)

| Reference | Children's complete vaccination history | History of children's vaccination against influenza | History of parents' vaccination against influenza | Confidence in vaccines | Confidence in COVID-19 vaccines | Vaccination hesitancy | Concerns for serious side effects and effectiveness of COVID-19 vaccines | COVID-19 vaccine uptake/intention among parents | Information based in the web/social media | Compliance with prevention measures/knowledge about prevention measures | High level of information about the COVID-19 pandemic/vaccination | Level of analysis |
|-----------|----------------------------------------|-----------------------------------------------|-----------------------------------------------|------------------------|-------------------------------|---------------------|--------------------------------------------------------------------------------|-----------------------------------------------|------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|-------------------|
| (Evans et al., 2021) | NS | NS | – | – | ↑ | – | – | ↑ | – | – | – | – | Multivariable |
| (Humble et al., 2021) | – | – | – | – | ↓ | – | – | – | – | – | – | – | Multivariable |
| (Kezong et al., 2021) | ↑ | – | – | – | – | – | – | – | – | – | – | – | Multivariable |
| (Lackner and Wang, 2021) | – | – | – | – | – | – | – | – | – | – | – | – | Multivariable |
| (Lunus et al., 2021) | – | – | – | – | – | – | – | – | – | – | – | – | Multivariable |
| (Tensah et al., 2021) | – | – | – | – | ↓ | – | ↑ | ↑ | ↑ | – | – | – | Multivariable |
| (Urrunaga-Pastor et al., 2021) | – | – | – | – | – | – | – | – | – | ↑ | – | – | Multivariable |
| (Xu et al., 2021b) | – | – | – | – | – | – | – | – | – | – | – | – | Multivariable |
| (Zhou et al., 2021) | – | – | ↑ | – | – | – | – | – | – | NS | – | – | Multivariable |
| (Galanis et al., 2021b) | – | – | ↑ | ↑ | ↑ | – | – | ↓ | NS | – | – |↑ | Multivariable |
| (Atad et al., 2021) | – | – | – | – | – | – | – | – | ↑ | – | – | – | Univariate |
| (Davis et al., 2020) | – | – | – | – | – | – | – | – | – | – | – | – | Multivariable |
| (Padhi et al., 2021) | – | – | – | – | – | NS | – | ↑ | – | – | – | – | Multivariable |
| (McKinnon et al., 2021) | – | – | – | – | – | – | – | – | – | – | – | – | Multivariable |
| (Shmueli, 2021) | – | ↑ | – | – | – | – | – | – | – | – | – | – | Multivariable |
| Positive associationa | 5/8 | 3/4 | 7/7 | 3/3 | 5/5 | 0/6 | 0/3 | 7/8 | 0/2 | 2/3 | 3/4 | – | – | Multivariable |
| Negative associationa | 0/8 | 0/4 | 0/7 | 0/3 | 0/5 | 5/6 | 3/3 | 0/8 | 1/2 | 0/3 | 0/4 | – | – | Multivariable |
| No associationa | 3/8 | 1/4 | 0/7 | 0/3 | 0/5 | 1/6 | 0/3 | 1/8 | 1/2 | 1/3 | 1/4 | – | – | Multivariable |

NS: non-significant.
↑ more likely to vaccinate.
↓ less likely to vaccinate.
- not investigated.

a Number of studies with a positive significant association (p-value < 0.05) between the predictor and parents’ willingness to vaccinate their children against the COVID-19/total number of studies examined the predictor.

b Number of studies with a negative significant association (p-value < 0.05) between the predictor and parents’ willingness to vaccinate their children against the COVID-19/total number of studies examined the predictor.

ca Number of studies without a significant association (p-value ≥ 0.05) between the predictor and parents’ willingness to vaccinate their children against the COVID-19/total number of studies examined the predictor.
The pooled proportion of parents that intend to vaccinate their children was higher in studies with high quality (62.0%, 95% CI = 53.1–70.4%, I² = 99.92%) than in studies with low/moderate quality (50.1%, 95% CI = 31.8–68.3%, I² = 99.4%). Similarly, the pooled proportion of parents that refuse to vaccinate their children was 21.6% (95% CI = 15.9–28.0%, I² = 99.84%) in studies with high quality and 28.0% (95% CI = 9.1–52.3%, I² = 99.67%) in studies with low/moderate quality.

Parents' willingness to vaccinate their children was higher in journal articles (60.7%, 95% CI = 51.8–69.3%, I² = 99.92%) than in pre-prints (56.1%, 95% CI = 41.1–70.5%, I² = 99.23%). Moreover, parents' refusal was higher in pre-prints (31.1%, 95% CI = 12.4–53.8%, I² = 99.6%) than in journal articles (21.6%, 95% CI = 15.9–27.8%, I² = 99.84%).

We found evidence that recruitment method affected parents' willingness to vaccinate their children. When data were collected through online surveys the proportion was 57.2% (95% CI = 47.2–66.9%, I² = 99.93%), and when data were collected through questionnaires in clinical settings the proportion was 69.2% (95% CI = 57.2–80.0%, I² = 99.49%). Similarly, when data were collected through online surveys the proportion of parents that refuse to vaccinate their children was 23.8% (95% CI = 17.1–31.3%, I² = 99.86%), and when data were collected through questionnaires in clinical settings the proportion was 20.4% (95% CI = 10.2–33.1%, I² = 99.51%).

There was evidence of differences in findings between studies in North America, Asia, and Europe. In particular, the proportion of parents that intend to vaccinate their children in studies that were conducted in Asia was 58.5% (95% CI = 51.0–65.9%, I² = 99.52%), in North America was 56.5% (95% CI = 48.2–64.6%, I² = 98.97), and in Europe was 47.9% (95% CI = 39.0–56.9%, I² = 98.84%). Additionally, the proportion of parents that refuse to vaccinate their children in studies that were conducted in North America was 31.5% (95% CI = 20.5–43.6%, I² = 99.41%), in Asia was 21.8% (95% CI = 14.1–30.5%, I² = 99.55%), and in Europe was 20.0% (95% CI = 4.0–44.1%, I² = 99.86%).

### 3.7. Risk of bias analysis

The predictors of parents' willingness to vaccinate their children against COVID-19 from high quality studies are associated with parents' willingness to vaccinate their children (no association in five studies). Health insurance, increased number of children, and children with chronic illness were non-significant predictors in 3/4, 7/11, and 8/10 studies respectively.

Positive attitudes regarding vaccination affected positively parents' intention to vaccinate their children against COVID-19. In particular, children's complete vaccination history (5/8 studies; no association in three studies), history of children's vaccination against influenza (3/4 studies; no association in one study), history of parents' vaccination against influenza (7/7 studies), confidence in vaccines (3/3 studies), confidence in COVID-19 vaccines (5/5 studies), and COVID-19 vaccine uptake/intention among parents (7/8 studies; no association in one study) were associated with increased intended uptake of a COVID-19 vaccine. On the other hand, overall vaccination hesitancy (5/6 studies; no association in one study), and concerns for serious side effects and effectiveness of COVID-19 vaccination (3/3 studies) decreased parents' willingness to vaccinate their children.

Moreover, higher levels of perceived threat from the COVID-19 (4/6 studies; no association in two studies), compliance with prevention measures (2/3 studies; no association in one study), trust in public health agencies/health science/physicians (3/5 studies; no association in two studies), and high level of information about the COVID-19 pandemic/vaccination (3/4 studies; no association in one study) were associated with parents' intention to accept COVID-19 vaccination for their children.

### 4. Discussion

To our knowledge, this is the first systematic review and meta-analysis that assesses the willingness and the refusal of parents to vaccinate their children against the COVID-19 and investigates the predictors for their decision. Forty-four papers including 317,055 parents met our inclusion criteria. The primary reasons that papers were excluded from our systematic review include irrelevant research questions and other types of publications (e.g. reviews, qualitative studies, case reports, protocols, etc.).

#### 4.1. Parents' willingness and refusal to vaccinate their children

We found that the overall proportion of parents that intend to vaccinate their children against the COVID-19 is moderate (60.1%) with a wide range among studies from 25.6% to 92.2%. Parents' intention to vaccinate their children against the COVID-19 is lower than the intention of the general population to take a COVID-19 vaccine (60.1% vs. 73%) (Snehota et al., 2021; Wang et al., 2021b). This finding is confirmed by a meta-analysis of large nationally representative samples where 72.9% of the general population intend to vaccinate against the COVID-19, 14.3% intend to refuse vaccination, and 22.1% were unsure (Robinson et al., 2021). Similarly, in our study 60.1% of parents intend to vaccinate their children, 22.9% intend to refuse vaccination, and 25.8% were unsure. Intentions and refusals vary substantially between studies included in both meta-analyses. Also, the willingness of high-risk groups such as healthcare workers to accept COVID-19 vaccination is higher than parents' willingness to vaccinate their children (63.5% vs. 60.1%) (Galanis et al., 2021; Luo et al., 2021). A possible explanation for the lower overall intention of parents to vaccinate their children against the COVID-19 demonstrated by our meta-analysis could be the perception of a very low risk of severe COVID-19 in children and the fact that children are often asymptomatic carriers. The wide range of parents' willingness among studies is confirmed by similar reviews in the general population and could be due to different study designs, study
conducted in clinical settings than in studies that were conducted online. The finding is debatable since previous studies have shown that lower educational level is associated with more concerns about vaccine safety and efficacy (Schaffer DeRoo et al., 2020). Also, behavioral-health officials should be informed to diminish parents’ concerns for COVID-19 vaccine. Leaders, and social influencers should be implemented by the public health authorities to diminish parents’ concerns for COVID-19 vaccine.

4.3. Predictors of parents’ willingness to vaccinate their children against COVID-19

According to our review, several sociodemographic characteristics affect parents’ willingness to vaccinate their children against COVID-19. In particular, mothers and younger parents were more hesitant, a finding that is confirmed by the literature since females and younger individuals are in general more likely to report vaccine hesitancy (Galanis et al., 2021a; Lin et al., 2020b; Neumann-Böhme et al., 2020; Schwarzinger et al., 2021). This could be due to the fact that males and older individuals, reported being at higher risk of intensive care unit admission and death from COVID-19, and so could be more prone to vaccination (Bienvenu et al., 2020; Peckham et al., 2020). On the other hand, females tend to experience more adverse events after COVID-19 vaccination and their vaccine hesitancy may be related to poor knowledge regarding issues such as fertility, pregnancy, and breastfeeding (Schrading et al., 2021; Xu et al., 2021a). Therefore, mothers could be more worried about potential side effects of the COVID-19 vaccines in their children, and thus are more reluctant to vaccinate their children.

Moreover, we found that educational level is a controversial issue regarding parents’ intention to accept a COVID-19 vaccine for their children. The impact of parents’ educational level on vaccine hesitancy is debatable since previous studies have shown that lower educational level is associated with more concerns about vaccine safety and efficacy (Gust et al., 2003; Shui et al., 2006; Smith et al., 2004), but other studies found the opposite (Opel et al., 2011). Also, a higher level of parents’ education is related to higher confidence towards vaccination by giving more tools for decision-making (Bocquier et al., 2018; Gualano et al., 2018; Kempe et al., 2020), but higher educated parents are more likely to forego immunizations (Gilkey et al., 2013; Smith et al., 2011).

Another interesting finding of our meta-analysis is the effect of the “unsure” response option in surveys. In particular, the presence of the “unsure” response option decreased both the intention of parents to accept a COVID-19 vaccine for their children and their refusal. A recent meta-analysis of samples from the general population confirms this finding since when there was no “unsure” response option the proportion of participants intending to vaccinate was 82.8%, and when there was an “unsure” response option the proportion was 63.5% (Robinson et al., 2021). Also, when there was no “unsure” response option the proportion intending to refuse a COVID-19 vaccine was 17.2%, while when there was an “unsure” response option the proportion was 12.4%.

It is noteworthy that our meta-regression analysis revealed that data collection time does not affect parents’ intention and refusal to vaccinate their children but studies of current and ongoing attitudes towards COVID-19 vaccination should be conducted since information and knowledge about COVID-19 vaccines are still evolving. In that case, the only significant relation we found was that over time intention not to vaccinate increased in studies with an “unsure” response option.

4.3. Predictors of parents’ willingness to vaccinate their children against COVID-19

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Our review revealed that parents from Black, Asian and minority ethnic groups are less willing than White parents to vaccinate their children against COVID-19. This is consistent with a systematic review which shows that COVID-19 vaccination uptake is higher among individuals from White race than individuals from Black race (Galanis et al., 2021a). Also, individuals from Black, Asian and minority ethnic groups have a lower level of COVID-19 vaccine acceptability (Funk and Tyson, 2021; Hamel et al., 2021; Malik et al., 2020; Ruiz and Bell, 2021) and they have lower seasonal influence vaccine coverage (Williams et al., 2017). Given that people from Black, Asian and minority ethnic groups are at higher risk of acquiring SARS-CoV-2 infection and at increased risk of adverse outcomes from COVID-19, a concerted effort must be made to minimize inequalities in COVID-19 vaccination uptake and ensure equitable access to the COVID-19 vaccines (Martin et al., 2020; Sze et al., 2020; Voysey et al., 2021).

We found that parents’ positive attitudes towards vaccination affect their decision to vaccinate their children against COVID-19. In particular, parents whose children had recently received the influenza vaccination or had a completed vaccination history reported a higher likelihood of COVID-19 vaccination for their children. During the COVID-19 pandemic, an important predictor of future behavior remains past behavior (Bourassa et al., 2020). Past behavior predicts future behavior in a direct pathway, where a habitual process occurring, or in an indirect pathway via conscious, intentional processes (Ouellette and Wood, 1998; Schwarzer and Hamilton, 2020). For instance, several studies have identified the relationship between individuals’ vaccination in the past and uptake of the pandemic H1N1 vaccine (Bish et al., 2011; Rubin et al., 2011; Setbon and Raude, 2010; Torun et al., 2010). This pattern is similar to our finding that COVID-19 vaccine uptake among parents is associated with increased intended uptake of a COVID-19 vaccine among children. Moreover, the COVID-19 pandemic seems to increase the polarization of parents’ vaccination behaviors since parents who did not vaccinate their children in the past reported becoming even less likely to vaccinate them in the near future (Sokol and Grunmon, 2020).

According to our review, confidence in vaccination, concerns for serious side effects and effectiveness of vaccines, and vaccine hesitancy are significant predictors of parents’ attitudes regarding vaccination. These findings are confirmed by the literature since parents in the USA are hesitant to vaccinate their children with routine immunizations because of safety, side effects and low effectiveness concerns (Kempe et al., 2020; Nyhan and Reifler, 2015). Vaccine hesitancy is a complex issue and one of the main obstacles to control the COVID-19 pandemic since an instrumental percentage of the general population refuses COVID-19 vaccines (Jaca et al., 2021; Wiysonge et al., 2021). Unfortunately, providing information on vaccine safety and effectiveness to individuals who are vaccine-hesitant can be counterproductive (Nyhan et al., 2014; Nyhan and Reifler, 2015; L. D. Scherer et al., 2016). Tailored and targeted communication materials and balanced information on vaccines providing both the benefits and risks of vaccination are necessary to optimize vaccine uptake (Dube et al., 2015; Dube et al., 2020). A robust, transparent, reasonable, and widespread COVID-19 vaccine educational campaign harnessing media, healthcare workers, leaders, and social influencers should be implemented by the public health authorities to diminish parents’ concerns for COVID-19 vaccine safety and efficacy (Schaffer DeRoo et al., 2020). Also, behavioral-change theories (e.g., the health-belief model) have already been effectively adapted to improve individual medical use and should be used by government and health authorities to curb COVID-19 vaccine hesitancy among parents (Lin et al., 2020a; Opel et al., 2009).

Since COVID-19 vaccine safety and effectiveness are key parental concerns, it is critical to emphasize the safety profile of COVID-19 vaccines for children based on evidence from randomized controlled trials and post-approval data. Well-informed parents experience less
worry, fear, and anxiety about COVID-19 and are more likely to receive a COVID-19 vaccine for their children as suggested by our review. The rigorous development and approval process of COVID-19 vaccines by the federal agencies worldwide increase parents’ concerns and there is a need for continued transparency and active public education regarding the development of the COVID-19 vaccines (Bell et al., 2020b; Lee et al., 2020). In that case, the role of primary care physicians to communicate about COVID-19 vaccines for children is critical since prior studies show that clear messages and recommendations by primary care physicians have a large impact on vaccine uptake (Braun and O’Leary, 2020; Dempsey and O’Leary, 2018; Edwards et al., 2016).

5. Limitations

This systematic review has several limitations. In particular, the statistical heterogeneity was very high due probably to heterogeneity in study designs and populations. To account for this heterogeneity, we applied a random effects model and we performed subgroup and meta-regression analysis. At least, subgroup analysis and leave-one-out sensitivity analysis revealed that our results are robust. We searched for studies conducted until December 12, 2021, but the availability of COVID-19 vaccines and evidence from randomized controlled trials and post-approval data are increasing on an ongoing basis and parents’ attitudes could be changed. Thus, our findings may not be generalizable to later in the COVID-19 pandemic. Since all studies in our review were cross-sectional, we cannot infer causal relationships between parents’ willingness to vaccinate their children against the COVID-19 and predictors of this attitude. Additionally, we included in our review articles in pre-print services which do not apply peer-review process. Thus, articles in pre-print services could be of low quality. To overcome this limitation, we assessed studies quality and we performed subgroup analysis according to studies quality and publication type. We consider predictors of parents’ intention to vaccinate their children as a potential area for future study since only sociodemographic variables have so far been investigated thoroughly. Future studies should assess broader and diverse parent populations to fully understand the factors that affect parents’ intention to vaccinate their children against the COVID-19. Finally, the proportion of parents that agreed to vaccinate their children against the COVID-19 may be a biased estimation since studies measured willingness and not COVID-19 vaccination uptake.

6. Conclusions

High vaccination coverage is indispensable to control the COVID-19 pandemic. Given the highly transmissible delta and omicron variants, COVID-19 vaccination coverage should be increased to achieve herd immunity to COVID-19. This is the main reason that the COVID-19 vaccine rollout is expanding to the children population. Thus, it is critical to better understand what factors affect parents’ decision to vaccinate their children against COVID-19. Understanding parental COVID-19 vaccine hesitancy does help policymakers to change the stereotypes and establish broad community COVID-19 vaccination. As global COVID-19 vaccines rollout continue, our review could help policy makers and healthcare workers to understand parental decision around COVID-19 vaccination. This information can be used for evidence-based targeted campaigns and health interventions to ultimately maximize future COVID-19 vaccine uptake among children. There is a need to build vaccine confidence during the COVID-19 pandemic through clear messages and effective community engagement. Targeted public health strategies should aim to assure parents’ concerns regarding COVID-19 vaccines. Identification of the factors that affect parents’ willingness to vaccinate their children against COVID-19 will provide opportunities to enhance parents’ trust in the COVID-19 vaccines and optimize children's uptake of a COVID-19 vaccine.

Funding

None.

Conflicts of interest

None. Supplemental data to this article can be found online at https://doi.org/10.1016/j.ypmed.2022.106994.

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