Acceptance and reluctance of COVID-19 vaccination among the general population: a systematic review and meta-analysis of cross-sectional studies

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SUPPLEMENTARY MATERIAL

Search strategy

A systematic search was conducted for the acceptance and reluctance towards COVID-19 vaccination as reported in the literature using a variety of sources; PubMed, Embase, and Google Scholar. This comprehensive search employed Boolean logic operators in conjunction with Medical Subject Heading (MeSH) ("AND," "OR," & "NOT). Furthermore, the missing information or full text articles were retrieved using topic of interest and disease specific search terms as: COVID-19 or 2019 novel corona virus or sarscov 2 infection or vaccines or COVID-19 shots and COVID-19 vaccine acceptance or COVID-19 vaccine reluctance or COVID-19 vaccine hesitancy or vaccination intention or world population or COVID-19 vaccination attitude, etc. The updation of the systematic search was done by a peer review process till July 31st, 2021. The search was limited to full-text publications solely in the English language.

Data extraction

Data extraction was done independently by three researchers (G.T., RK.P, and P. B.) through literature screening and tabulation in a pre-designed data sheet. Differences in the summary of the results were discussed and dealt with by the two researchers and all the disagreements were resolved by the third researcher (P.B). The initial screening, which consisted of reading the title and abstract, was completed, as was the secondary screening, which consisted of reading the entire content. The screened articles were entered into Zotero reference manager software (Zotero version 5.0) to remove the duplicates by screening the title, author, journal and year of publication. Ultimately, discussion and a repetition of the steps led to the resolution of the conflicts among the writers (PBS, and RK.P). Every study that was chosen for the systematic review underwent a thorough and independent evaluation by three critical appraisers (P.B.,B.S and G.T.). Disagreements between the two primary reviewers were settled by VR.N. and S.R., the third and fourth reviewers.

Analysis of the included studies

The articles that met the inclusion criteria were categorized into those that assessed the acceptance rate, those that assessed the hesitancy, and articles aimed at assessing both acceptance and hesitancy. After the articles were examined, the following information was taken out to a Microsoft Excel sheet: authors, year of publication, country/city where the survey was carried out, study design, study tool, sample size, criteria for inclusion and exclusion, number of responses, vaccination acceptance rate, hesitancy rate/refusal rate, determinants of vaccination acceptance and hesitancy, including the age, gender, educational and occupational status, place of dwelling of the study population, their beliefs, perceptions, and attitude towards vaccination. The data was then analysed and the results were tabulated.

Supplementary Material Table. 1 Variables associated with the determinants of COVID-19 Vaccine Acceptance

S.No	Study design, Author, year and (N)	Data collection technique	Inclusion criteria	Exclusion criteria	Study outcome	Vaccine acceptance rate (%)	Reasons for vaccine acceptance
1	Cross sectional survey Al-Mohaithef et al., 2020 [23] (N=992)	Web based. A bilingual, self-administered anonymous questionnaires.	Age 18 and above	Not mentioned	64.7% intended to take the vaccine, only 7% reported hesitancy and 28.2% were reported "not sure" about their intention	64.70 %	old aged participants, perceived risk of becoming infected, higher trust in the health system
2	Cross Sectional Survey Faasse K et al., 2020 [25] (N=2174)	Online Promoted Survey,Questionn-aire (Facebook Advertisement)	Advertisements were targeted at all users with current country of residence listed as Australia and age listed as 18 or above.	Not mentioned	Four in five respondents indicated that they would definitely (60.4%) or probably (20.8%) get a vaccination. 12.3% were unsure, 3.7% were probably not to get the vaccine, and 2.8% definitely not got vaccinated.	60.40 %	Having received a seasonal flu vaccine in the past year, increased exposure to media coverage and heightened worry or concern about the outbreak, greater scientific and medical understanding of the virus, confidence in government information, and higher knowledge scores
3	Cross Sectional Survey Kreps S et al., 2020 [28] (N=1971)	Online (Lucid Platform)	Not mentioned	Not mentioned	First systematic evidence of factors associated with individual preferences toward COVID-19 vaccination	79 %	Consistent with previous research, vaccine efficacy,
4	Cross Sectional Survey Lazarus JV et al., 2021 [29] (N=7423)	Online	Not mentioned	Not mentioned	14.0% completely agreed, 25.9% somewhat or completely disagreed There was considerable variation by country.	71.50 %	People earning more, higher levels of education, cases and mortality per million population, trust in government
5	Cross Sectional Survey Machida et al., 2021 [30] (N=2956)	Internet based Questionnaires	20 to 79-year-old men and women from all regions of Japan	Not mentioned	Women, aged 20–49 years, with no underlying diseases, not married, with a low educational level, and a low annual personal income had a	62.10 %	Perceived likelihood of being infected, Perceived severity of a COVID-19, Perceived effectiveness of a COVID-19, Willingness to protect others by getting oneself vaccinated and Doctor's

					high likelihood of getting a COVID-19 vaccine.		recommendation
6	Cross-sectional survey Wirawan GBS et al., 2021 [32] (N=779)	Online survey promotion materials, including online pamphlets and URLs	Aged 18 or older and have been resident of Bali since July 2019 at the latest.	Duplicate entries, respondents with incomplete responses from analyses.	The level of vaccine acceptance, which was moderately high	60.80 %	Vaccine acceptance was correlated with conspiracy beliefs, trusts in conventional media and authoritative sources
7	Cross-sectional survey Sherman SM et al., 2021 (N=1500)	Online research panel	18 years or over and lived in the UK	Not mentioned	64% were very likely, 27% were unsure and 9% reported being very unlikely to be vaccinated.	64 %	older age, having been vaccinated for influenza last winter, perceiving a greater risk of COVID-19, COVID-19 vaccination beliefs and attitudes, weaker beliefs of side effects or be unsafe.
8	Cross-sectional Survey Wang J et al., 2020 [33] (N=2058)	Online survey platform (stratified random sampling method)	Chinese respondents aged 18 years and above residing in Mainland China on the Wen Juan Xing sample database	Not mentioned	A strong demand for the vaccine and the high recognition of the importance of vaccines in controlling pandemics.	91.30 %	Gender, marital status, risk perception, influenza vaccination history, belief of COVID-19 vaccine efficacy, valuing doctor's recommendations, vaccination convenience or vaccine price.
9	Cross-sectional survey Martin CS Wong et al., 2021 [34] (N=1200)	Questionnaire based on the HBM previously designed.	aged ≥ 18 years who could communicate in Chinese	Not mentioned	Overall, 42.2% of study participants indicated acceptance of COVID-19 vaccine, while 17.4% expressed unwillingness, and 40.4% indicated not sure.	42.20 %	Trust in the healthcare system and the vaccine manufacturers
10	Cross Sectional Survey Wong LP et al., , 2020 [35] (N=1159)	Web based anonymous survey using an online questionnaire.	Malaysian residents who were between 18 and 70 years of age.	Not mentioned	Overall high acceptance., Males had greater odds of a definite intention to take the COVID-19 vaccine than do females.	94.30 %	Belief that vaccination decreases the chance of COVID-19 infection; vaccination makes them feel less worried about COVID-19

Supplementary Material Table. 2 Variables associated with the determinants of COVID 19 hesitancy

S. No.	Study design, Author, year and (N)	Data collection technique	Inclusion criteria	Exclusion criteria	Study outcome	Vaccine hesitancy rate (%)	Reasons for vaccine hesitancy
1	Cross-sectional online survey Elise P et al., 2021 [37] (N=2361)	Online weekly data collection, non-random	Individuals who had started the vaccine module administered from 7 September to 5 October 2020	Participants with any missing data, individuals who had selected "other" in response to gender and "prefer not to say" on ethnicity	Very likely to be vaccinated: 64% ; Unsure/uncertain about vaccination: 23% Very unlikely to be vaccinated: 14 %	37 %	7.2% - High mistrust of vaccine safety; 17.2% - Uncertain about their levels of trust; 16.3%- Expressed strong worries about unforeseen effects; 52.9% - Moderate worries; 8.1% - Strong concerns & 28.8% moderate concerns about commercial profiteering; 8.5% - Strong preference for natural immunity; 44.7% - Natural immunity might be better than a vaccine
2.	Cross sectional survey Michal S t al., 2021 [38] (N=1942)	Online survey research panel	Representative of adults aged 18–64 years residing in France	0, 58 (2·9%) reported previous SARS-CoV-2 infection and were excluded from the experiment.	Refused: 29 %; Hesitant: 43%; and only 27% accepted vaccination	72 %	Distrust in the effectiveness and safety of new COVID-19 vaccines, lower compliance with immunisation in the past, lower perceived severity of COVID-19

Supplementary Material Table. 3 Variables associated with the determinants of both COVID 19 acceptance and hesitancy

S. No.	Study design, author, year and (N)	Data collection technique	Inclusion criteria	Exclusion criteria	Study outcome	Vaccine acceptance rate (%)	Reasons for vaccine acceptance	Vaccine hesitancy rate (%)	Reasons for vaccine hesitancy
1	Cross-sectional Survey Akarsu et al., 2021 [22] (N=759)	Online Survey (social media and Smartphone Users)	All individuals above 18 years of age using social media and smartphone in Turkey.	Not mentioned	Not mentioned	38.4 %; 3.5 % if its free	To protect self and the family, particularly the children	14.8%, 43.2% undecided	Afraid of side effects, not reliable, biological weapon

#	Study	Sampling	Age criteria	Exclusion	Acceptance results	Acceptance rate	Associated factors	Hesitancy/refusal	Reasons
2	Cross-sectional online survey Bendaui A et al., 2021 [24] (N=1779)	Social media platforms (Twitter, Facebook, Instagram), news portals.	Minimum age of 18 years, the ability to complete the survey in German language, and the current place of residency in Germany.	Not mentioned	64.5% - accept it, 13.8% -rather accept it, 10.4% - undecided, 5.2% would rather not 6.0% absolutely not get vaccinated.	64.50%	COVID-19-related anxiety and health-related fears	6.0%	Fear of social and economic consequences showed the contrary direction.
3	Cross-sectional survey Fisher KA et al., 2020 [26] (N=991)	members were contacted and enrolled via telephone, mail, and in-person field interviews.	Not mentioned	Participants who did not respond to the question on intent to be vaccinated	When a vaccine for the coronavirus becomes available, will you get vaccinated?": "yes," "no," and "not sure." *Intent to Be Vaccinated, by Participant Characteristics	57.60%	Not mentioned	10.8%, and 31.6% not sure	Specific concerns about the vaccine (Side effects, safety, Efficacy), Antivaccine attitudes, beliefs and emotions, Lack of trust
4	Cross sectional Survey Study Roselinde et al., 2021 [27] (N=2698)	Nationally representative panel of the market research agency Dynata	Aged above 18 years and living in Belgium	Excluded because they did not meet the company's internal quality controls (e.g., they completed the survey unreasonably fast).	34% (N = 651)- "definitely" become vaccinated and 39% (N = 742)-"probably" become vaccinated , 18% (N = 346) - "probably not" and 9% (N = 165)-"definitely not".	73%	Educational attainment was significantly and increasingly associated with positive opinion about vaccination in general	27%	Lack of awareness on the consequences of not vaccinating

| 5 | Cross sectional Study Rana A et al., 2021 [31] (N=1500) | Survey conducted in social media platforms (Facebook, WhatsApp, Instagram, and Twitter) | Not mentioned | Not mentioned | Only 24.9% of the participants (n = 728) showed acceptance of receiving an available COVID-19 vaccine, while 32.6% (n = 955) were hesitant, and the rest of them denied the willingness to take it . | Total- 24.9%; of which; Jordan - 17.1%; Lebanon- 18.5%; Saudi Arabia 29.4% Iraq - 34.7% | Living in Saudi Arabia and Iraq, being unmarried, having monthly income > $1,000, holding a medical degree, having high fear from COVID-19, feeling of being at risk of getting infected with COVID-19, and previous reception of influenza vaccine | 32.6% - hesitant 42.5% denied | Female sex and previous infection with COVID-19 |
| 6 | Cross sectional survey Wang CS Martin et al., 2021 [34] (N=1200) | Online survey questionnaire. (Wechat, Weibo) | Above age of 18 years and living in China. | IP addresses that were duplicated or outside the mainland of China, quality issue, logical error. | Nine provinces with COVID-19 vaccination willingness rates under 65%. Highest rate of vaccine hesitancy was observed in Tibet (55.8%). | 67.10% | People's trust in the vaccine, delivery system, and government | 35.50% | Safety of the COVID-19 vaccine, low efficacy of the COVID-19 vaccine |

Supplementary Material Table. 4   Checklist for quality assessment of included studies

Study	Q-1 Sample frame that addresses the specific audience	Q-2 Appropriate selecting methods	Q-3 Sufficient sample sizes	Q-4 Study participant and setting characterisations	Q-5 Enough statistical investigations	Q-6 uses appropriate techniques for the aforementioned parameters	Q-7 Uses valid measurements for all the study subjects	Q-8 Use of appropriate statistical analysis	Q-9 An adequate response rate
Akarsu *et al.,* 2021 [22]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Al-Mohaithef *et al.,* 2020 [23]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bendau Antonia *et al.,* 2021[24]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Faasse K *et al.,* 2020 [25]	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Fisher KA *et al.,* 2020 [26]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Roselined K *et al.,* 2021 [27]	No	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear
Kreps S *et al.,* 2021 [28]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Lazarus JV *et al.,* 2021 [29]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear
Machida *et al.,* 2021 [30]	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rana A *et al.,* 2021 [31]	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	Yes
Wirawan GBS *et al.,* 2021 [32]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Sherman SM *et al.,* 2021 [39]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wang J *et al.,* 2020 [33]	Yes	Unclear	Yes	Yes	Yes	No	Yes	Yes	Yes
Martin CS *et al.,* 2021 [34]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wong LP *et al.,* 2020 [35]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes
Wang Cho *et al.,* 2021 [36]	Unclear	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear

Supplementary Material Table. 5 Quality assessment of the Studies using JBI Critical appraisal tool

| Appraisal Items	Responses					
	Yes		No		Unclear	
	n	%	n	%	n	%
A sample frame that addresses the specific audience	15	83.3	2	11.1	1	5.56
Appropriate selecting methods	16	88.8	0	0	2	11.2
Sufficient sample sizes	18	100	0	0	0	0
Study participant and setting characterisations	17	94.5	0	0	1	5.56
Enough statistical investigations	15	83.3	1	5.56	2	0
Uses appropriate techniques for the aforementioned parameters	14	77.8	3	16.6	1	5.6
Uses valid measurements for all the study subjects	18	100	0	0	0	0
The use of appropriate statistical analysis	16	88.8	0	0	2	11.2
An adequate response rate	15	83.3	0	0	3	16.6
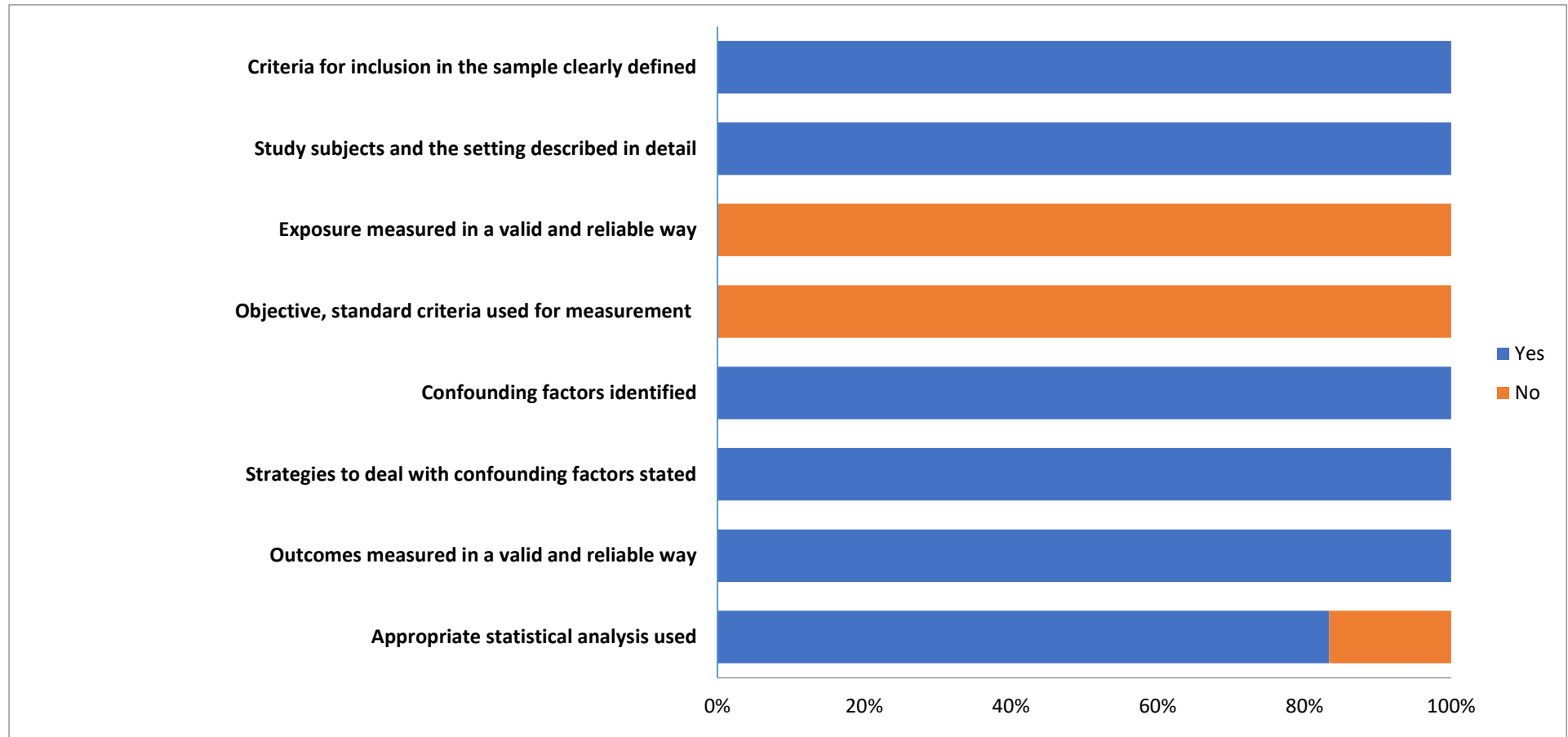
Fig. 1: Bias risk in the included studies (based on the Critical Appraisal Checklist for Analytical Cross-Sectional Studies developed by the Joanna Briggs Institute).

Supplementary Material figure 2. Funnel plot